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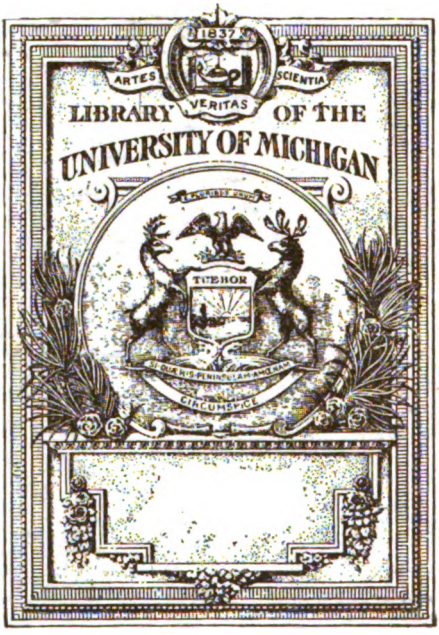

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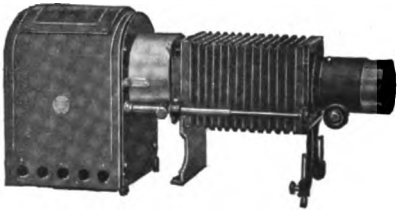

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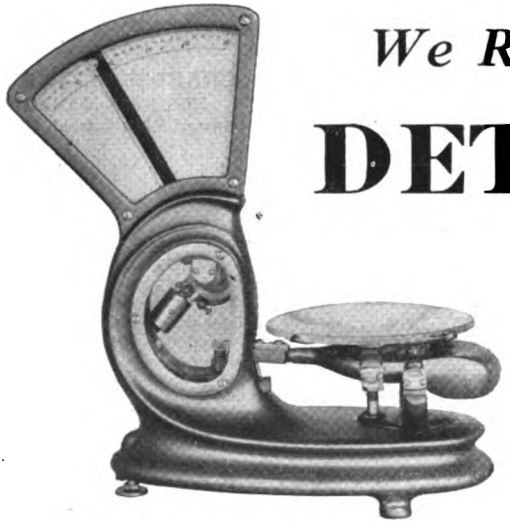

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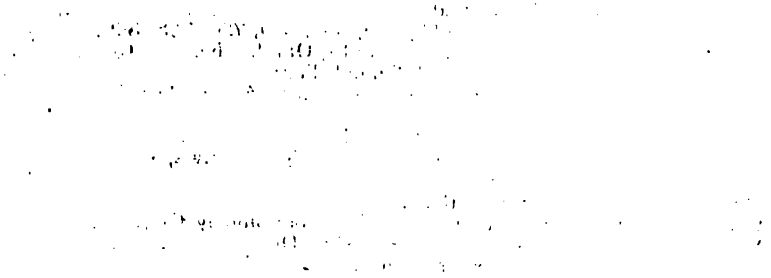

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CONCERNING EXPERIMENTS TO TEST THE TRANSFER OF TRAINING.

BY J. W. A. YOUNG,
The University of Chicago.

What follows is written from the point of view of a worker in mathematics who usually turns to that subject for his concrete illustrations; but the discussion is not, in the main, more relevant to the subject of mathematics than to other subjects.

For many centuries, mathematics has been taught in the belief not only that much of its content is of great practical usefulness, but also that a suitable study of the subject affords valuable mental training. So widespread has been this belief, and so satisfactory the outcome of the myriad annual repetitions of the test in the laboratory of experience, that up to this day mathematics is taught as a subject required of all in the elementary and secondary schools of practically the whole civilized world.[1] The belief was based at each period on general educational theory current at that time, supported by the outcome in practice. It was by no means *proved* to be correct in the sense in which proof is understood in mathematics.

Within the last decade or two, however, a more or less definite impression has gained currency to the general effect that psychologists have been making laboratory investigations of the processes of mental training whose results have *proved* that mental power gained in the study of some one subject cannot be applied in another; that old "doctrines" have been "exploded"; that the day of educational theorizing is past; that henceforth educational problems will be taken into the psychological laboratory and *solved;* that a formula for dealing

[1] Moreover, there is a remarkable similarity in the scope and even in the details of the ground covered, as well as in the character and the methods of instruction. It is the judgment of all civilization that a certain minimum of mathematics, which is about the same the world over, should be obligatory for all pupils. (See the reports presented to the International Congress of Mathematicians at Cambridge, England, in 1912. With respect to curricula, these reports have been summarised by J. C. Brown, in Bulletin No. 619, 1914, of the U. S. Bureau of Education, Washington, D. C. As long as the supply lasts, the Bulletin may be obtained free on application to the Bureau).

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with each particular problem will be discovered and *proved*, just as in mathematics. Naturally, all this must be very pleasing to those working in the field of mathematics—the science of actual proofs. One imbued with the mathematical ideal will always prefer to base his actions on facts, on known truths, rather than on theorizings and suppositions. But, of course, he will wish to get his facts at first hand, or as nearly so as possible. In the particular matter in question, he would certainly wish to learn from the psychologists themselves what they have proved, and not at second, third, or *n*th hand

With this attitude of mind, I began a goodly number of years ago to try to ascertain from psychologists in person and in their own first-hand publications, just what they have actually accomplished; what are the known *facts* concerning transfer of training.

And on entering the field of first-hand psychological literature itself, I found, just as I expected to find, the calm and serene atmosphere of science. I found careful statement of particular experiments and not sweeping generalizations on the basis of meager data; I found that psychologists of the first rank were quietly doing their work and presenting the results for what they might be worth; and that the explosions which were to overturn the entire educational edifice were taking place chiefly in the regions of rumor and misconception.

So far as I myself was concerned, I found nothing that was not consonant with the views that I had held as to the purpose and value of the study and teaching of mathematics in elementary and secondary schools. In fact, I found myself confirmed and supported in those views. But I had no means of knowing that I had found all the relevant literature, and I hesitated at offering to a wider public a summary of the facts as I had found them, lest it should turn out that I had not found and considered results of dominating import.

But, fortunately, a recent publication enables me to present such a summary with a certificate of completeness from a prominent psychologist who is an authority in this particular field. Namely, in *Monograph No. 16* of the *Educational Psychology Monographs*, the editor, Professor Guy Montrose Whipple, of the University of Illinois, states that this "monograph presents in a compact, semitabular form, a valuable and comprehensive

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summary of all the experimental work that has been done upon formal discipline to date."[2]

With the boundary of completeness thus authoritatively fixed, I present in the sequel a brief sketch of the experiments listed by Rugg. The presentation is based in part on the original memoirs, in part on Rugg's monograph, whose order I follow. It is obvious that any description in a few words of a voluminous memoir must be indequate. The most that can be hoped is that these few words may give the reader a general idea of the character of the psychological investigations in question and of their results.

The theorizing, I leave to the reader. This bird's-eye view puts him into the position to do the following:

(1) To examine the literature in detail, by following up the references given.

(2) To decide for himself, what modifications, if any, the results of these experiments require him to make in the views he has hitherto held as to the purpose and value of the teaching of his subject.

(3) To pass intelligent judgment upon claims that may be made at second, third, or *n*th hand to the effect that psychologists have "proved" this or "exploded" that.

Detailed references to the original publications concerning each experiment are given in a table at the end of the paper. In addition, mention should be made of:

Thorndike, E. L., *Educational Psychology*, 3 vols. 2d ed., New York, 1913-14.

Heck, W. H., *Mental Discipline and Educational Values*. London and New York, 1912.

But one reading in this field for the first time should by all means begin with Rugg's monograph.

[2]The monograph in question is entitled, *The Experimental Determination of Mental Discipline in School Studies*, by Harold Ordway Rugg. Published by Warwick & York, Baltimore, Md., 1916.

Professor Whipple was formerly connected with Cornell University; he is one of the Editors of the *Journal of Applied Psychology* and also one of the editors of the *Journal for Educational Psychology*, the chief single organ in the United States of the type of work here under consideration. He is the author of a *Manual of Mental and Physical Tests* (second edition, revised and enlarged, 2 vols., together 717 pp., large 8vo., 1914-15), which impresses me as a thorough and scholarly work, full, clear, and easily readable. In the *Psychological Bulletin*, March, 1917, p. 105, it is stated that this manual "serves as the standard reference book to which one who is to make tests naturally turns to consult before determining upon his method and to get a starting point for a study of the literature."

Accordingly, Professor Whipple speaks with the authority of a specialist of high standing in this very field when he tells us that Rugg's monograph covers "all the work done upon formal discipline to date."

Of course, I take this statement in a figurative rather than in a strictly literal sense. It is difficult to guarantee literal completeness. I know of researches (some of them indeed listed in Whipple's bibliographies, and doubtless he and Dr. Rugg know of still others), for whose inclusion a more or less strong claim might be made. But their inclusion would not alter the total picture. I accept Whipple's guarantee to the effect that we have in the researches listed a picture that is essentially complete and that we can from it ascertain the actual upshot of the experimental work to date. If anyone should wish to question this, it would not be sufficient to claim that certain other investigations should have been included; this would be a mere quibble unless accompanied by proof that their inclusion would have altered the outcome materially.

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Power Trained, Studied, or Tested.	Remarks; Results.
I. James, 1890. Memorizing verse.	Practice in memorizing verse by other writers caused little or no improvement in memorizing verse by a given writer. The conditions of the experiment are not exactly stated.
II. Peterson, 1912. James' experiment repeated.	Considerable improvement followed training. But several of the untrained control group showed as much gain.
III. Ebert and Meumann, 1904. Memorizing series of numbers, nonsense syllables, letters, unrelated words, stanzas of poetry, paragraphs of prose.	The training and test series were of the same general character. On the whole, marked improvement in ability to memorize them was found after training.
IV. Dearborn, 1909. Repeated Ebert and Meumann's test series to find what improvement is obtained from practice incident to the tests.	Found large improvement of this character.
V. Dearborn, 1910. Memorizing English, French, German, Norse verse, etc.	Six subjects were trained on French or German vocabularies, six on various kinds of verse. Almost all showed improvement in the test material, though not so much as in the training material. Thus, a subject who was trained on French vocabulary and showed fifty-seven per cent gain therein, showed twenty-five per cent gain in (untrained) memorizing of French verse. One trained on Horace's Odes with a gain of seventy-three per cent, showed a gain of but seventeen per cent in (untrained) memorizing of Norse poems. A gain of sixty-eight per cent in memorizing "Paradise Lost" was followed by no gain in (untrained) memorizing of chemical formulas.
VI. Winch, 1908. Memorizing passages from book on history for ten minutes with reproduction at once.	Group A was trained for two weeks in memorizing poetry. Group B worked sums while Group A practiced memorizing. Otherwise the work of the two groups was exactly the same. Group B showed marked improvement in the test memorizing. Group A showed slightly more. The experiment was repeated with different groups with the same results.

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VII. Fracker, 1908. Memory for: Poetry. Order of four shades of gray. Order of nine tones. Order of nine shades of gray. Order of four tones. Order of nine geometric figures. Order of nine numbers. Extent of arm movement.	Practice was given on memorizing the order of four tones. The practiced group (eight individuals) made a greater percentage of improvement in each type of memory tested than did the untrained group (four individuals). The greatest difference of improvement was found in the case of four grays, the next in the case of four tones, and the least in the memory for the extent of arm movement.
VIII. Winch, 1910. Memory for substance of passages read.	Rote memory gained by practice; substance memory showed some improvement.
IX. Sleight, 1911. Ability to memorize spatial relations, dates, nonsense syllables, poetry, prose, etc.	Groups of girls and women were trained in various types of memorizing. The untrained control groups showed practically as much gain as the trained groups. Over one hundred persons altogether.
X. Thorndike, 1901. Estimating areas of rectangles.	Training on rectangles of a certain shape produced improvement for rectangles of the same area but different shape, though the degree of improvement was not so great as in the training set.
Estimating weights.	Analogous results.
Perceiving words containing two given letters.	Training in perceiving words containing *e* and *a* gave improvement in perceiving words containing other combinations, as *i* and *t*, *s* and *p*, *c* and *a*, *e* and *r*, and in perceiving A's and misspelled words, but the improvement was not so great as for the combination used in training.
Perceiving a given part of speech.	Training in verbs produced a slight reduction for other parts of speech accompanied by an *increase* of over one hundred per cent in omissions.
XI. Judd, 1902. Strength of the illusion: ><———— <————>	Two subjects (trained observers) were given practice on hundreds of such figures. The illusion gradually disappeared. There was transfer of skill gained by practice, in spite of varying conditions.
XII. Coover and Angell (F), 1907. Discrimination of shades of gray.	Four individuals were given practice in discriminating intensity of sound. All the individuals but one showed improvement in discriminating shades of gray. No untrained comparison group is mentioned.

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XIII. Bennett, 1907. Discrimination between: Shades of red. Shades of yellow and green. Shades of black and orange.	Sixteen children, aged about eleven, were trained in discriminating between shades of blue. There was marked improvement in discriminating between the other shades. No untrained comparison group is mentioned.
XIV. Scholkow and Judd, 1908. Holding pencil in direction indicated by lines.	Practice with one line, affected success with all other lines.
XV. Kline, 1909. (1) Cancelling parts of speech. (2) Substituting digits for other symbols, and vice versa.	Subjects were trained in crossing off *e*'s and *t*'s; also in substituting digits for letters. In the final tests, they showed: In (1), only a slight gain. In (2), much less improvement in the test series than in the training series; in a few cases, there was actual retrogression on the test series.
XVI. Wallin, 1910. Control of reversions in reversible perspective outlines (such as pyramids, etc.).	Training of one eye caused gain in the unpracticed eye.
XVII. Whipple, 1910. Influence of training on quickness of visual perception.	Nine subjects were trained by objects exposed for a short time; e. g., cards with five to seven printed letters, were exposed 8/100 sec.; stanza of poetry exposed three seconds. The effect of training was little or nothing.
XVIII. Foster, 1911. Somewhat analogous to the work of Whipple.	Three adults were trained and showed only slight improvement.
XIX. Dallenbach, 1914. Analogous to the work of Whipple.	Twenty-nine school children were trained, and there was a control group of fifteen untrained children. The effect of training persisted fifty weeks and spread to other functions.
XX. Gilbert and Fracker, 1897. Reaction to stimuli: sounds, electric shocks, certain blows, sight of blue surfaces.	Three subjects were trained in reaction to sounds. If no discrimination is involved, the gain for other untrained stimuli is almost equal to that for those used in training. If the test required discrimination and choice but the training did not, there was no reduction after training. But practice in discrimination of sounds reduced the time of discrimination for other forms of stimuli.
XXI. Jastrow, 1896. Magicians Hermann and Kellar tested as to	Ability resulting from one very "specialized form of training may

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sensibility, quickness, estimates of distances, etc., in comparison with groups of college students.	be only slightly influential upon other forms of capacity."
XXII. Bair, 1902. (1) Tapping letters on six labeled keys of typewriter. (2) Repeating alphabet forward, backward; also each way with letter *n* named between each letter.	The subjects were four college students. All showed decided effects of practice.
XXIII. Leuba and Hyde, 1905. Reading German script; writing translations of it into English and vice versa.	Forty-two college students were trained in writing or reading German script. There was a large percentage of gain; as much as 230 per cent.
XXIV. Ruger, 1910. Solution of mechanical puzzles.	There was evidence of some transfer.
XXV. Bagley and Squire, 1905. Neatness.	For a period of three weeks, the teachers insisted on neatness in all work in arithmetic. There was an average gain of 4.1 per cent in neatness in arithmetic, but a *loss* of 2.1 per cent in language, and 2.3 per cent in spelling.
XXVI. Ruediger, 1908. Neatness.	Thirty-nine children in seventh grade were divided into three groups. In each group, emphasis was put on neatness in *one subject* only, for a period of eight weeks. The percentage of gain in neatness was small but nearly as large in the subjects where no emphasis was laid on neatness as in those where it was emphasized.
XXVII. Bennett, 1907. 1. Perception of pitch. 2. Perception of letters at different distances. 3. Reaction time. 4. Rate of marking A's. 5. Auditory memory of figures. 6. Logical memory of simple passages. 7. Quickness in naming colors.	College students were tested in the freshman year and again in the senior year. About five-eighths of the tests showed gains; the remainder showed no change or slower deterioration.
XXVIII. Briggs, 1913. Influence of three months' training in formal grammar on such abilities as: To see likenesses and differences.	In instances there was evidence of some transfer. In the majority of cases there was no such evidence. W. C. Bagley points out various inadequacies in the conduct and

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	To judge a definition. To make a rule. To select pertinent facts and use them properly.	the report of the experiment (*Jour. Educ. Psychol.*, September, 1914).
XXIX.	Wallin, 1911. Effect of drill in spelling.	All that is obtained from drill is increased facility to master new forms. Spelling drill does not "produce a universal, generalized spelling proficiency which will spread to *all* words whether these have been studied or not."
XXX.	Rugg, 1915. Effect of a semester's training in descriptive geometry on mental manipulation of spatial elements that are: (a) of nongeometric character; (b) quasi-geometric; (c) strictly geometric.	Four hundred and thirteen engineering freshmen studying descriptive geometry were compared with eighty-seven students of the College of Engineering and of Education not taking descriptive geometry. The study of descriptive geometry operated so as to increase substantially abilities in all lines mentioned.

The number of subjects that participate in an experiment is of considerable significance. If it is large, individual variations in conditions that affect the outcome may be regarded as more nearly averaged than when it is small. On account of the difference between adult and child psychology, results obtained by adults and children under the same conditions might well be quite different. In judging the import of the results of an experiment, it is of consequence to know whether or not there was formed for comparison a group of subjects who were not trained but who took the initial and final tests. In some cases, the number of subjects is mentioned in the summary above. The following table (based on Rugg, p. 11), gives the numbers for all the experiments. When various numbers participated in different parts of the experiment, the largest number is given. The subjects were adults, except when "ch" follows the number.

Experiment	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Trained Group	5	2	6	?	12	27 ch.	8	23 ch.	18+84ch.	6
Untrained Group	0	7	0	?	0	27 ch.	4	23 ch.	?	0

Experiment	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.
Trained Group	2	4	16	3+1 Gp.Ch	9	2	6	3	29 ch.	3
Untrained Group	0	2	0	1 GroupCh.	9	0	0	0	15 ch.	0

Exp'm't	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.	XXVII.	XXVIII.	XXIX.	XXX.
Tr'n'd Grp.	2	4	26	27	1 Gp.Ch	39 ch.	145	130 ch.	1022 ch.	413
Untd. Grp.	1 Group	0	0	0	1 Gp.Ch	?	0	61 ch.	0	87

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We have now before us a compact summary of "all the experimental work on formal discipline that has been done to date" (date of copyright, 1916). To determine what effect the results of this work should have upon educational views is an individual matter. The effect obviously depends upon what views the individual has held previously. Each individual must theorize for himself. If he considers the different mental powers to be "like different tanks or reservoirs with many pipes emptying into them and many draining out of them," and if he holds that "no matter through what pipe water gets into the tank it can go out by any other pipe and continue almost unchanged through the entire process,[8] he will find little support in the results of the above experiments. But who has ever held these views?

The reader who is disposed to do so may weigh the experiments by comparing the outcome that actually occurred with what his common sense would lead him to expect. If he finds, as I imagine he usually will, that the actual outcome agrees substantially with his common sense expectation, he will be encouraged to trust his common sense more than ever before, and will find in these experiments new support for the educational views which his common sense and experience had led him to hold.

As to bearing on transfer, Rugg classifies the experiments as follows:

(1)	Showing no transfer (including one doubtful)	5
(2)	Slight gain indicates some transfer	17
(3)	Clear evidence of considerable transfer	10
(4)	Experimenter claims large amount of transfer (unsupported by evidence)	3
		35

Five experiments were entered twice; two under (1) and (2), and three under (2) and (3). This accounts for the discrepancy between the thirty-five entries and thirty experiments.

Taken as a whole, the body of experiments tests discreet special abilities selected here and there from a very wide field and leaves many questions practically untouched, including the important one of training in reasoning. Almost none of the experiments have been repeated even a second time; the results are far from being scientifically established by numerous repetitions with concordant outcomes. What outcome there is gives distinct support to the belief that the results of training

[8] Hook, p. 160.

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can be transferred, and that educational work has disciplinary as well as content value.

I add no further discussion for the present. In a subsequent paper, I shall give some of my own comments.

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THE FUNDAMENTAL RELATION OF BOTANY TO SCIENTIFIC AGRICULTURE.

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There is, at present, a strong sentiment coming from many quarters, against the old type of botany that has been, and is still, taught in many schools. The purely scientific study of plant life has lost ground, while the practical phases, which may be included, in a general way, under elementary agriculture, have gained rapidly. In these times of change in educational thought, there is great danger of going to extremes and thereby throwing aside much that is valuable. Consequently, a consideration of the fundamental relations of the scientific study of the plant to agricultural practices is in place.

The green plant occupies an entirely unique position in the world about us. It stands, as it were, between the organic and inorganic; between man's needs and the simple chemical compounds of the soil and air; between the sum and the energy requirements of virtually all living things. It is the green plant that is instrumental in bringing together the carbon dioxide of the air and the water of the soil, thereby producing the substance out of which the food supply of all higher forms of life, as well as that of the vast majority of the lower forms, is produced. The welfare of all living things is bound up with the welfare of the plant.

The green plant is the central figure of agriculture. The grain farmer, the stockman, the fruit grower, the gardener, all must sooner or later give it their most careful thought. The agronomist studies the chemistry of the soil; he adds limestone here and phosphate there; he investigates the effects of deep and shallow cultivation; he determines the crop rotation to be used; he studies the bacterial content of the soil and the effect of these organisms upon the availability of the mineral nutrients. All these investigations have a single aim—a better understanding of the conditions most favorable for plant life. The great central problem of present-day agriculture is concerned with the life of the plant and the necessary conditions for its optimum development and productivity.

If this is a true statement of the fundamental problem of agriculture, and I do not believe it can be questioned, if the plant stands at the focus of agricultural thought, and if the scientific investigations pertaining to the soil have as their final aim the improvement of the conditions for plant develop-

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ment, then it follows that a clear and concise understanding of the fundamental structures and processes of the plant should be an essential part of any general course, worthy to be called scientific agriculture. The plant is a living thing and truly wonderful in its organization. It reacts to stimuli with precision. It ceases to develop when conditions are unfavorable for the carrying on of its life processes. It dies when subjected to influences to which the animal organism is immune. Identical causes will produce identical results here, as in the physical world. Law rules in the plant kingdom just as it rules elsewhere. Consequently, agricultural methods and practices must conform to the demands of the plant. If the plant fails to develop and to produce as it should, the manner and conditions of cultivation are at fault. Scientific agriculture must find the remedy. The knowledge of the structures and life processes of the plant itself is the only true, scientific guide to this end. It is true that valuable discoveries have been made by haphazard use of the "trial and error" method, without any knowledge of the organisms concerned, but this surely cannot be considered the true scientific procedure. True advance follows the investigation of the cause of a phenomenon. The time is not far distant when it will be generally recognized that it is just as important, from the standpoint of scientific advancement, for the agricultural student to understand the fundamental physiology of the plant, as it is for the medical student to understand the physiology of the human body. Surely, the proper kind of botany is essential in the study of scientific agriculture.

The kind of botany that will meet the needs of agriculture is a question of prime importance. The stand against botany as it has been, and still is, taught in many places, is, in my opinion, well taken. The botanists themselves are largely responsible for the condition. In this day when science is being applied so largely to the practices of everyday life, the demand has gradually arisen for the type of botany that will throw light upon the practical things in the home, on the farm, and in the community, concerning which there is a widespread and permanent interest. Instead of meeting this need, the botanist has been handing out a sort of boiled-down college botany suitable only for the specialist in biology—work that is of scientific interest, to be sure, but work that is of a type that scarcely touches the life of the average boy or girl, who, at most, can devote but a few months to this subject. This sort of botany

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can have but a remote relation to agriculture. The botany that agriculture needs is, first of all, a scientific and thorough study of the fundamental structures and processes of plant life. The work must not be superficial. The few words devoted to the fundamental structures and processes of plants, as given in some very highly recommended agricultural texts, can never form a real basis upon which to build. In the second place, the material for study should be selected, as far as possible, from the important agricultural plants. The science of alfalfa and the corn plant is surely just as good as the science of the orchid and the marine alga. And, lastly, the fundamental and practical principles developed in these studies should be applied, where possible, directly to the agricultural practices without delay.

A course, such as this, is of great value, not only from the scientific but also from the applied standpoint. The principle developed in the study of the plant possesses a new meaning and an intensified interest when it is applied to the practical things of life. The scientific facts and principles underlying pollination, fertilization, and asexual reproduction, become subjects of supreme interest when they are connected up with things of practical life such as the selection of seed corn in the field, the breeding of animals and plants, and the preservation and multiplication of new varieties in horticulture. Where is the boy or girl who will be listless and inattentive as this tremendously important subject matter is carried over to explain the phenomena of everyday life! On the other hand, a boy who has a clear conception of the principle involved in an agricultural practice, becomes far more independent and intelligent in the application of this principle to the problems of the farm life. Surely it is hardly reasonable to expect a person to apply knowledge, intelligently, which he does not possess. It is true that a carefully worded direction may be followed, and good results obtained, so long as the conditions involved in the process remain unchanged, as is seen in the bread-making of our mothers, and in the legume crops of our fathers. But when the original set of conditions ceases to exist, and complications arise, then the knowledge of the principle involved becomes a necessity, if the person is to succeed in his undertaking. Doubtless the boy who is familiar with the life relations of the oat smut is more reliable when it comes to applying the formaldehyde treatment than he who blindly attempts to follow a set of directions.

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There are difficulties to be encountered in the closely correlated courses of botany and agriculture that I am advocating. Too frequently the botany work is done by a teacher who knows almost nothing about the agricultural practices and has no conception of the problems the agriculturist must meet. With a teacher of this type, in a school where agriculture is an important line of work, I believe it is scarcely possible to have botany work that means much to those taking elementary agriculture. The teacher who does not have some definite knowledge of the practices and problems of the farm has little to guide him in his selection of suitable materials with which to develop principles that throw light upon the agricultural practices. Too frequently, also, the teachers of elementary agriculture, and sometimes those teaching advanced courses, have little conception of the important structures and fundamental processes of plant life. Under these conditions, the elementary agriculture is likely to degenerate into a superficial treatment of the subject that has no claim to be called scientific. An understanding of the principles involved, so far as it is possible to understand them, is a prime essential in a truly adequate course in scientific agriculture.

A man far advanced in his chosen line stood before his botany class composed largely of agricultural students, and virtually said to them by his manner and by his entire lack of knowledge concerning the common practices of agriculture, "I cannot help you in the application of these botanical principles, for I know nothing about agriculture, and, moreover, I care little about the subject. I am a botanist." Not far away another teacher, just ready to take the master's degree in agriculture, stood before his class in elementary agriculture and said in substance to his students, "You will recall that the *entire* root system of a plant is *completely* covered with root hairs, and that it is through these structures that the soil water enters the plant, after which it passes upward through the *cambium* layer." A splendid exhibition of profound ignorance of simple botanical facts! This actually took place, and, what is more, there is evidence that this sort of thing, in one form or another, is occurring all too frequently in our schools today. Such conditions should be unheard of where agriculture is taught, but this will come to pass only when teachers of botany and agriculture prepare themselves more broadly for their respective lines of work.

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Closely correlated courses in the important phases of biology under consideration are scarcely possible, in my opinion, so long as the teacher of agriculture deals exclusively with the application, and the teacher of botany deals only with the principle. The teacher of agriculture should not hesitate to go over into purely scientific botany to review, or to teach again, if necessary, the fact or process which he is applying in his own work. On the other hand, the teacher of botany should not hesitate to carry the fact or principle he has just presented over into the field of agriculture and to apply it with sufficient detail to give to the student a definite understanding of its practical importance. An example will make my meaning clear. In the botany class the root systems of plants have been studied in detail. The students have become familiar with the form, structure, extent, and distribution of roots, and also with the origin, structure, distribution, and function of root hairs. After these facts are well in mind, then is the time for the teacher to connect these things with the agricultural practices concerning the structure, aeration, and water content of the soil. Likewise, when the teacher of agriculture deals, in detail, with soil physics, it is his opportunity to go into the field of scientific botany and to correlate his work on the soil with the structures and physiology of the plant root. This procedure, properly carried out by the teachers of botany and agriculture, would serve to bring these intimately related phases of biology into their proper relation to each other. If a teacher who is thoroughly prepared in botany as well as in agriculture teaches both lines of work, the problem of correlation, obviously, becomes easy.

There are other sides of this subject that are well worthy of consideration here, such as the proper preparation of the teacher, and the problem of the textbook, but I shall omit these and close with a very brief statement of my chief line of thought. 1. The central figure in scientific agriculture is the plant. 2. Botany is the science of the plant. 3. Scientific agriculture cannot be separated from the scientific study of the plant—that is, from botany. 4. The scientific study of principles and the practical application of these principles should form closely correlated courses for elementary students in agriculture. 5. The proper correlation of botany and agriculture is not a difficult problem if the teacher of botany has sympathy for, and a knowledge of, present-day agriculture, and if the teacher of agriculture is familiar with the fundamental structures and processes of the plant.

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BUSINESS METHODS IN THE SELECTION OF LABORATORY APPARATUS.

By Ernest Carroll Faust,
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This paper is written from the combined point of view of the teacher experienced in the use of physical and biological laboratory apparatus, and of one who, as a sometime employee of a large factory and jobbing house, has familiarized himself with the commercial handling of such apparatus. Some four thousand orders for laboratory equipment have come under the writer's attention. They comprise requisitions from all types of schools all over the United States and Canada, as well as certain ones for export shipment.

Firms which handle laboratory supplies for educational and commercial laboratories may be classed as manufacturers, large and small wholesale and retail jobbers, and local retailers. There is a certain advantage in purchasing certain articles from each of these houses. A purchase from the manufacturer insures fresh stock and prevents inferior substitutions. It also makes possible the ordering of piece apparatus from individual design for individual needs. The jobbing house handles the bulk of the trade, due to a greater variety of stock and to the fact that many manufacturers do not deal directly with the purchasing public. An order placed with a reliable jobber who carries a large stock is usually satisfactory. The local retailer in the city or small town may be relied on for small quantities of staple articles, and is a convenience at all times. Often he will save money and time. However, a large and comprehensive selection of equipment for all types of laboratories cannot be secured in entirety from any one of these concerns. For that reason some five or six firms in this country both manufacture certain articles for the trade and act in the capacity of large jobbing houses, carrying an ample stock from which the needs of the laboratory may be supplied. Some of these concerns manufacture physical apparatus and job biological and agricultural equipment. Others are specialists in optical goods. The writer knows of no firms which manufacture laboratory glassware or chemicals and job general laboratory equipment. From the double point of view from which the writer's experience has been secured, the most satisfactory concern for the buyer is one which specializes in the manufacture of general

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physical apparatus for the laboratory, and jobs chemicals, glassware, biological and agricultural supplies.

Just as the firms handling laboratory apparatus differ in the amount and variety of stock which they have on hand, so the purchasers differ in their desires and needs. The selection of apparatus for laboratories in private and public secondary schools, normal schools and colleges, universities, and experimental stations, schools large and small, differs profoundly. On the whole it has been repeatedly observed that public high and normal schools have the most generous appropriations for their equipment. The colleges and universities are much more specific in their needs and much more exacting in requiring their orders to be filled to specifications. It must be admitted that selection of apparatus by high and normal schools often shows poor judgment. Is this due to the greater amount of money at their disposal? By far the most extensive and expensive equipment is shipped to agricultural laboratories in public high and normal schools.

In order that the reader may know something of the actual types of orders that are sent to the shipper, certain instances will be cited and certain errors in ordering pointed out.

The large supply houses publish comprehensive catalogs of their goods, assigning to each article a certain number. This number is usually a key to the position of the item in the stock room. Consequently an order is most satisfactorily filled which lists the articles desired in sequence order, with the addition of the name and special size of the item. Such an order saves time in the office, in the stock room, and in the shipping room. Where a chance assortment of items is listed in the invoice, errors may result at the hand of the clerk in the office or order room, or even by the checker or packer. Yet only a small minority of customers, perhaps ten per cent, list the items desired in systematic fashion.

Confusion in filling an order is frequently caused by lack of specification of items. Orders are frequently received by the jobber which would require an omniscient order clerk to interpret. "Rubber stoppers to fit test tubes" is a request found in certain orders where no test tubes are ordered. The customer may be aware that test tubes range in length from 1½ to 12 inches, and in diameter from ¼ to 1 inch; and that rubber stoppers are made solid, one-hole, or two-hole. More probably the buyer exhibited a lack of care in making out the order.

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Again microscopic slides and covers are requested, without reference to size or shape. While the catalog may list the green flint slides with rough edges under a different number from the white slides with ground edges, and the square covers from the circles, the thickness of the former and the thickness and size of the latter may require specific notation. If no. 1 22mm. squares are wanted, and no. 2 18mm. squares are sent, the customer is dissatisfied, but whose fault is it, if the size has not been specified?

It is not advantageous to order a staple article in small quantities from a laboratory apparatus company when that article can be purchased from a local merchant. An order for "five pounds of flour," or a "a can of baking soda," a "spool of white thread," or "five yards of white cloth," or "a dozen thumb tacks," is an item that will often have to be provided for outside of the firm. The firm will oblige the customer in order to keep the trade, but will charge for the extra accommodation. A special messenger may have to be sent half-way across the city to procure the spool of thread. The "dozen thumb tacks" must be taken from a box of one hundred, and the time of the order picker is paid for by the customer. The writer realizes that many school directors will O. K. a bulk shipment from a single firm, while they will look askance at a large number of trivial requisitions. In such cases it is the duty of the teaching corps to educate the directors to see cost values.

At times, purchases of heavy articles of small value are made for long distance shipment. Sometimes the purchase is large enough to justify the item; more frequently it is not. The shipper is compelled to pack and label items according to prescribed regulations of the Interstate Commerce Commission. If "ten pounds of marble chips" or "Mason fruit jars" must be packed separately in order to conform to the rules laid down, the expense of packing and freighting is not justified.

The writer has attempted to place briefly before the laboratory teacher the "other man's point of view," and to show how certain methods of selection of apparatus will conserve time and money and eliminate error.

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A SIMPLE RULE FOR EXTRACTING ANY ROOT OF A NUMBER.

By Otto Dunkel,
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In the November, 1916, issue of School Science and Mathematics, Mrs. M. W. Arleigh gave an interesting method for computing the square root of numbers. This method permits of an easy extension by means of which a good trial selection may be made for the following figure after a certain number of figures have been found. Thus in the identity used by Mrs. Arleigh $x^2-y^2=(x-y)(x+y)$, if we suppose that x is the root of the number, say of 5347, and y is the approximation already found, then $x-y$ is the correction to be added to this approximation in order to have the correct root. Since x and y do not differ greatly, $x^2-y^2=(x-y)2x$ approximately, and we find for $y=70$ that $x-y=447/140=3.+$. Hence 3 is a good number to try for the second figure. With this addition, however, the completed method does not differ essentially from the ordinary method.

Various methods, at least eight, have been devised for finding the square root of numbers, some of which are rather complicated and difficult in application. For finding a long string of the decimal figures one at a time, perhaps no method is more convenient and easily applied than Horner's Method, if the method of contracted division is used. But the theory of this process is not simple. There is one method, however, which is extremely simple in theory and application. It has been known for a long time and is really a modification of a much older method, called Newton's Method. The method has already been described by Professor E. R. Hedrick in his article, "Approximations and Approximation Processes," in the December, 1908, number of School Science and Mathematics, pages 749,750, but on account of its simplicity and value, and the fact that it seems to be so little known, I shall restate the rule and the principle of its working.

If we wish to find an approximation to $\sqrt{5}$, we first make what we regard as a good guess, say 2.5. We then test 2.5 by dividing 5 by it, for, if it is correct, then the quotient will be also 2.5; if it is too large, then the quotient will be too small, and conversely. In the two latter cases the correct root must lie between the divisor and quotient, and we select very naturally for the second approximation the number half way between the two, or their average. In this simple example the first computa-

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tion can be made mentally, and we obtain 2.25 for the second approximation. We now repeat this process with 2.25 as a divisor, finding 2.2222.. as the quotient, and we see at once that the first two figures, 2.2, are correct. But the average 2.2361 is still better and, in fact, is correct as far as it goes. For most practical cases this would suffice, but a third application of the method would give nine correct decimals. In general, if a certain number of decimal figures are known to be correct, then the next step will give twice as many more correct decimals. When the exact quotient is used the average is always larger than the root.

This method is very conveniently used with a table of square roots. If, for example, we have a table giving square roots to four decimals, and we desire more, then a division and average will give the same figures in the table, except perhaps the last one, and twice as many more decimals. The process works whatever may be the first choice, but the better this choice the more rapid is the calculation.

It is easily seen how to extend the method to the extraction of any root. Thus to find $\sqrt[3]{9}$ we select a trial number, say 2, and to test it we divide 9 by its square. We obtain the quotient 2.26+, which shows just as before that 2 is too small and 2.26+ is too large. To make a good selection of a number between the two we again take the average of all the found factors of 9, i. e., of 2, 2, 2.26, and we obtain 2.08+. If we repeat the process with 2.08, the division soon tells us that these figures are correct, and again the average will be very much better. In this particular case the average in this second step yields a result correct in the first eight decimals.

DEEP SALT BED.

In Kansas a deep well struck rock salt at 690 feet below the surface and penetrated 600 feet of rock salt in beds from 5 to 60 feet thick, according to the United States Geological Survey, Department of the Interior. A large area in this state is underlain by salt, which is mined by many shafts and obtained by pumping brine. Drilling for oil in Texas and Louisiana has revealed the presence of tremendously thick deposits of rock salt at a depth of a few hundred feet. Thicknesses of 2,000 feet are common, and one drill hole passed through more than 3,000 feet of rock salt. Most of the salt made in Utah is produced by evaporating the water of Great Salt Lake, and in California by evaporating sea water. These sources are inexhaustible, and the limit of production by solar evaporation will therefore never be reached.

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LOGARITHMS AND SOME OF THEIR APPLICATIONS FOR HIGH SCHOOL PUPILS.

By J. S. Counselman,
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Logarithms continues without doubt to be the most useful subject in elementary algebra. This is true in spite of the fact that the invention of such wonderful devices as the slide rule as well as the large amount of computation in all branches of engineering appearing in the form of handbooks, to say nothing of similar publications by construction companies, insurance companies, banks and other financial concerns, has somewhat diminished their practical value.

The teaching of logarithms in our modern high school is justified mainly on account of its practical value, therefore it does not seem advisable to carry the study of the theory too far. Dr. J. W. A. Young, a leading American authority on the teaching of mathematics, says, "The theory and practice of logarithms is naturally a part of the study of exponents and does more than anything else to give the subject of exponents a real meaning. It is a pity that the two subjects are ever divorced. Some drill in the manipulation of exponents is necessary, but the essence of these laws will be more deeply impressed by using them to abridge computation. It is only when thus used that the student is impressed with the great computational power gained by working with exponents."

Upon taking up the study of logarithms the following definition commonly in use should be clearly and definitely impressed. The logarithm of a number is the index of the power to which the base of the system must be raised to equal a given number. This can be done by having the pupil show that the log 1000 to the base 10 is 3.

After the student has been required to obtain by his previous study of exponents the logarithms of all numbers which are integral powers of 10 from 1000 to one ten-thousandth, he is then ready to be introduced to a table of logarithms. When a sufficient amount of drill has been given to insure a skilful use of the tables, the following equations, which express the fundamental principles involved in computation by logarithms, should be presented and simple proofs required or offered.

$$\left.\begin{array}{lll} \text{I.} & \log pq = \log p + \log q. & \\ \text{II.} & \log \frac{p}{q} = \log p - \log q. & \text{The base being understood,} \\ \text{III.} & \log k^n = n \log k, & \end{array}\right\}$$

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As soon as the pupil has been given a sufficient understanding of these equations to enable him to interpret them he should be required to apply all the principles contained therein by writing the value of logvx in several equations similar to the following:

$$x = \frac{c^2\sqrt[3]{d}}{m^{\frac{1}{2}}\sqrt[5]{n}}.$$

In order to provide sufficient time for the little theory that has been outlined and thorough drill upon the tables with applications to follow, some of the following topics might be partially or toally omitted:

1. Complex cases of removal of parentheses.
2. Cube root of polynomials and numbers.
3. The Euclidean method of finding the H. C. F.
4. The more difficult problems in factoring.

The application of logarithms to the extraction of cube and fifth root impresses the student with their great usefulness, and furnishes a clear understanding of the relation between characteristic and mantissa, besides inuring a valuable drill upon the tables since both the logarithm of a number and the antilogarithm are to be found alternately. In teaching this application care should be used to select a list of numbers such that the characteristic of their logarithm shall alternate between positive and negative numbers.

The following formulas, $v = \pi r^2 a$, $v = \frac{4}{3}\pi r^3$, and $v = \frac{a^3}{12}\sqrt{2}$ expressing the volumes of a circular cylinder, sphere, and regular tetrahedron respectively, are well adapted to computation by logarithms, and should be familiar to the student on account of his previous study of solid geometry. Their solution by logarithms furnishes a valuable review of this important subject.

The application of logarithms to compound interest seldom fails to arouse the pupil's interest since it has to do with the earning power of money. After the following equations, which express the relation between principal, rate, time, and amount, have been explained to the pupil, he should be required to solve them by logarithms for each letter appearing in the formula.

$a = p(1+r)^n$ where interest is compounded annually.

$a = p\left(1+\frac{r}{2}\right)^{2n}$ where interest is compounded semiannually.

$a = p\left(1+\frac{r}{4}\right)^{4n}$ where interest is compounded quarterly.

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Such problems occurring in everyday life as the following can be much more readily solved by logarithms than any method previously known to the student of elementary algebra.

Find the amount of $500 with interest compounded annually at six per cent, the time being five years, four months, and twenty-seven days.

Substitutions in the first of the above compound interest formulas should be made thus:

$$p = 500,\ r = 6\% = .06,\ n = 5+\frac{4}{12}+\frac{27}{360} = 5\frac{49}{120} \text{ or } \frac{649}{120}.$$

$$\text{Then } a = 500(1.06)^{\frac{649}{120}},\ \text{and } \log a = \log 500+\frac{649}{100}\log 1.06.$$

Hence a = $685.25.

A more interesting application of logarithms than any of the foregoing is the problem to be solved by the Farm Loan Bank in determining the equal, annual, semiannual, quarterly, and monthly payment necessary to pay off a loan with interest. The following table now in use by our Government gives the annual installment necessary to discharge a loan of $1,000 with interest, the number of years and rate of interest being indicated in the table.

FOR LOAN OF $1,000.

Years.	Five Per Cent.	Six Per Cent.
10	$129.50	$135.87
15	96.34	102.96
20	80.24	87.18
25	70.95	78.23
30	65.05	72.65
35	61.07	68.97
40	58.28	66.46

What more practical problem could be presented to the high school pupil than that worked out by our Government in the effort to assist the farmer upon whom we are all so dependent? This problem may be solved either by mathematical induction or as a geometric progression. Its partial solution by mathematical induction can be made clear to the average high school pupil if presented and solved in this manner: A man owes $\$p$ bearing simple interest at r per cent. He wishes to discharge both principal and interest by making three payments of $\$x$ each at the end of one, two, and three years. Solution: p times $r = pr$ = Interest for one year. $p + pr - x$ = Amount due and bearing interest after first payment. By repeating these calculations twice more, and remembering that debt should be discharged after three payments are made, we obtain in the above symbols:

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$p+3pr+3pr^2+pr^3-r^2x-3rx-3x = 0,$

Hence $x = \dfrac{p(1+r)^3}{r^2+3r+3} = \dfrac{p(1+r)^3}{1/r[(1+r)^3-1]} = \dfrac{pr(1+r)^3}{(1+r)^3-1}.$

If 4 payments are made, $x = \dfrac{pr(1+r)^4}{(1+r)^4-1}.$

If (n) payments are made, $x = \dfrac{pr(1+r)^n}{(1+r)^n-1}.$

When applying this formula to a loan of $1,000 bearing simple interest at six per cent, when payments are to be made at the end of each year for ten years, we should make the following substitutions: $p = 1000$, $r = 6\% = .06$, $n = 10$, the number of payments. Hence:

$x = \dfrac{1000(.06)(1.06)^{10}}{(1.06)^{10}-1}$. Now let $y = (1.06)^{10}$,

Then $\log y = 10 \log 1.06,$

$= .25310,$

and $y = 1.791.$

Then $x = \dfrac{1000(.06)(1.791)}{.791} = \$135.86.$

This formula is much better adapted to solution by logarithms when applied to this similar practical problem: A makes a loan of $2,000 bearing simple interest at six per cent. He wishes to pay $30 at the end of each month from date of loan until the debt with interest has been discharged. Find the number of payments he must make and the total amount paid out.

Since $x = \dfrac{pr(1+r)^n}{(1+r)^n-1}$, we have $(1+r)^n = \dfrac{x}{x-pr}.$

Let r = monthly rate $= \dfrac{.06}{12} = .005$ and $p = 2000.$

Then $(1.005)^n = \dfrac{30}{30-10} = \dfrac{3}{2}$, and $n \log 1.005 = \log 3 - \log 2.$

Therefore $n = 81.1014.$

Amount paid out $= 30(81.1014) = \$2,433.04.$

Some teachers in the past have been content to give the pupil a mere introduction to this subject. Now that the importance of algebra in our high school courses is being questioned, all should realize that a thorough working knowledge of such a vitally important topic as logarithms must be enforced if the subject is to maintain its former high rank in the curriculum

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THE STATUS OF MATHEMATICS IN SECONDARY SCHOOLS[1].

By ALFRED DAVIS,

Francis W. Parker School, 330 Webster Ave., Chicago.
Chairman of a Committee Appointed by the Mathematics Club of Chicago.

One might judge by the criticisms that come from certain quarters that algebra and geometry are in a precarious situation. Some would-be reformers would have us abandon the teaching of these subjects in high school in favor of what are said to be more useful subjects. Others would make them optional studies, or they would devitalize them by making them an easy and pleasant pastime for all who are required to take them. Still others would have us believe that the public is demanding such changes as these, and that it is only a matter of time until algebra and geometry as cultural studies are relegated to the scrap heap. It is a matter of considerable interest to know what persons outside the mathematical world, and who are qualified to speak of the subject, have to say as to the importance of mathematics in our scheme of education.

Our committee, representing the Chicago Mathematics Club, sent the following letter to prominent doctors, lawyers, merchants, bankers, etc., in the city of Chicago. We have avoided for the most part members of the teaching profession:

"The undersigned committee of the Chicago Mathematics Club, in cooperation with a National Committee of the Mathematical Association of America, is investigating the reasons for teaching mathematics in our secondary schools. We respectfully submit the following questions to you in order that we may have the benefit of your practical experience. Furthermore, your name will give to your answers a weight not attached to the opinions of persons less well known:

"1. Was the study of high school mathematics worth while to you? If so, why?
"2. Did its study contribute to your development anything which could not have been secured in equal degree from some other study which might have been substituted for it?
"3. In employing a young person or in advising him to follow your profession, what importance would you attach to a good school record in mathematics?
"4. In planning the secondary education of your son or daughter, would you include algebra and geometry? Why?
"5. Is a knowledge of algebra or geometry of any practical value in your business? If so in what way?
"6. Do you think algebra and geometry should be retained in our secondary schools?

"Your answers to these questions will be of great value to those who are striving to secure for our schools the best possible

[1]This part of the report was read before the Club at its regular October meeting, October 6, 1917.

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course of study, and your assistance will be greatly appreciated by our committee."

Fifty-five replies have been received as follows:

Physicians and surgeons	7
Lawyers	12
Bankers	7
Merchants	4
Engineers	1
Clergymen	9
Manufacturers	2
Authors and newspaper writers	2
Social workers	1
Business managers	1
Economist	1
Real estate men	1
Broker	1
Typefounder	1
Railroad men	2
Secretaries	2
Printers	1

Answers to question 1:

Affirmative	43
Very emphatic	7
Reasons assigned:	
Mental training	27
Training in accuracy	5
Training in concentration	3
Pleasure	3
Practical value	2
Preparation for engineering	2
Preparation for physicians	3
Preparation for college	3
Negative	6
Reasons:	
Never used it	1
Of little value	1

Answers to question 2:

Affirmative	36
Very emphatic	9
Uncertain	8
Negative	6
(No reasons given, no comment.)	

Answers to question 3:

Great importance	19
Banker	3
Engineers	1
Physicians	2
Lawyers	3
Merchants	2
Clergymen	2
Brokers	1
Printers	1
Manufacturers	2
Railroad men	1
Considerable importance	21
Bankers	3
Physicians	2
Economists	1
Lawyers	7
Clergymen	4
Railroad men	1
Real estate men	1
Secretaries	1
Very little importance	2
Lawyer and social worker.	
No importance	3
Physicians	2
Typefounder	1

Answers to question 4:

Both	42
Algebra at least	3
Neither	2
Only as a prerequisite for professional work	3

Answers to question 5:

Affirmative	23
Physicians	3
1, Biological chemistry, microscopic study.	
1, Absolutely essential for science involved in medicine.	
1, Necessary in vital statistics.	
Lawyers	5
Engineers	1
Bankers	4
1, Investment mathematics.	
1, Refers to the graph as important.	
Writers	1
Mentions its value in allusion.	
Ministers	2
1, Logical help.	
1, Argument and persuasion.	
Real estate man	1
Manufacturers	2
Economists	1
Statistics and city planning.	
Printer	1
Railroad man	1
Negative	26
Bankers	3
Lawyers	5
Clergymen	5
Merchants	3
Physicians	4
Social worker	
Broker	
Typefounder	
Railroad man.	

Answers to question 6:

Affirmative	46
Very emphatic	14
For professional preparation only	2
Optional	2
Negative	2

The following additional information contained in the replies is of considerable interest:

Mr. John G. Shedd, President, Marshall Field and Company: "I firmly believe in the value of mental training derived from the study of mathematics, both the elementary and the higher branches. I know that training has been of especially great value to me, and the principles are constantly used in everyday business transactions. It seems to me that the aim of all branches of a school curriculum should be the development

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of analytical and logical thinking by the student. Nothing in my judgment tends more to this than thorough training in mental and written mathematics."

Mr. C. F. Hoerr, President, Home Bank and Trust Company: "I should certainly consider it a serious mistake if algebra and geometry were not a part of the education of our children. I should want them to have algebra and geometry for a number of reasons:

"1. For the development of their reasoning and logical powers, and the concentration these subjects will demand.
"2. In case the children should want to major in any of the sciences.
"3. As a matter of general culture and training whether they desire to so major or not.

"Statistics are coming into their own, and the question of graphs is very important. We are making use of graphs in our business, and I feel that through this medium of presenting statistics we are better posted in our business."

Mr. G. M. Reynolds, President of the Continental and Commercial National Bank: "In planning the education of a child of my own I should insist upon algebra and geometry; for while only a few cases might occur in which the business man would make practical use of either, the mental training acquired in gaining a knowledge of algebra and geometry is of very great help in directing modern business, which is constantly becoming more complex by reason of increasing burdens—a condition which calls for the highest degree of preparation that the schools can give."

Mr. James B. Forgan, Ex-President, First National Bank, answers the questions as follows:

"1. Fifty years have passed since I studied mathematics in school. I have always thought that it, better than any other study developed my mind along the line of concentration of thought on problems confronting me. It was a study I liked and in which I excelled.

"2. Yes, the power of concentration, and I know of no other subject that if substituted for it, in my case, could have attained as good results.

"3. I would regard a good school record in mathematics as indicating a mind trained to concentration of thought on problems until they are solved.

"4. Yes.

"5. Arithmetic sufficient.

"6. I do."

Rabbi Emil G. Hirsch answers as follows:

"1. It was. I had, even as a lad, a knack for languages. Be-

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fore I was twelve years of age I spoke four and read eight. Mathematics provided for me the balance wheel.

"2. It did. It taught me to reason in abstract relations.

"3. Soundness of judgment, I hold, is apt to be better developed, and sequence of thought as well.

"4. I should include both. Educationally both are effective. Practical advantages—perhaps the discovery of mathematical bent in him.

"5. Not directly but indirectly it is—reasons given above.

"6. I do most emphatically. High schools are not factories turning out, one tracked minds."

Mr. H. H. Kennedy, lawyer, Moses, Rosenthal and Kennedy, answers as follows:

"1. Unqualifiedly yes. It is my judgment that the study of mathematics very materially assists in developing the reasoning faculties of the mind, and powers of anaylsis.

"2. Yes, because I do not believe there is any study taught in the high school that would tend to develop in an equal degree the faculties of the mind referred to. Logic, in my judgment, is merely a higher form of mathematics; a person who is a good mathematician is invariably a good logician.

"3. In advising a young man to enter upon the profession of the law, I would urge him to take up mathematics above all other subjects in the high school, since I believe that the primary essential to qualify a person to successfully practice law is the mental faculty of reasoning and the power of analysis. It also tends to develop the powers of abstract thought to a much higher degree than any other subject taught in the high school and especially the powers of concentration essential to success in any profession, and more particularly the law. Should a young man come to me with an exceptionally good record in mathematics, I should conclude therefrom that he had a well developed mind, and was especially fitted to practice law, for the ability to reason well and the power to concentrate are evidence of a good legal mind.

"4. Yes, I would most certainly include these two studies in planning for the secondary education of my son; indeed, I pursued this very course, and in connection with his studies at the University High School and Princeton University I urged upon him the importance of these subjects, and he pursued this course, his intention being to enter later upon a legal education.

"5. A lawyer enjoys a particular advantage if he is well

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equipped in algebra and geometry; he finds himself brought into all forms of intellectual inquiry which require abstract thinking; familiarity with these subjects comes into play every single day; and the principles of geometry are the foundation of logic.

"6. By all means. The science of algebra deals with representations of facts and permits the easier handling of them by the mind. A person well versed in algebra is especially qualified to detach himself from the facts of life in such a way as to enable him to reach conclusions free from bias or personal interest. It is unquestionably true that a lawyer who is a good mathematician is almost invariably a lawyer of ability, because he has a trained mind that enables him to stand upon his feet and reason well."

Thomas E. Donnelley, President, R. R. Donnelley and Sons Company, Director of the Chicago Directory Company, answers as follows:

"1. Yes, it trained me to think along logical lines and it gave me a clear idea of the necessity of being 100 per cent accurate.

"2. Yes, there is no study that could possibly take its place.

"3. I would not employ him unless he was good at mathematics.

"4. Yes, both, and trigonometry as well. It is the science of facts as they are. Anyone who doesn't understand these studies lacks an appreciation that things happen because they must.

"5. Yes, it gives one the ability to solve a problem.

"6. Yes. Who on earth thinks otherwise? It is the basis of our whole industrial life."

Judge E. O. Brown of the Appellate Court answers as follows:

"1. It was. I cannot for myself conceive why mathematical truths (which seem to me to be the thoughts of God before time was) should not be worth any man's study.

"2. It did.

"3. I should advise any young person to study mathematics and to obtain as good a school record as he could in them.

"4. I would—and did with my three sons and two daughters. Because I consider them very important branches of knowledge and very stimulating in intellectual pursuits.

"5. I hardly know what meaning to attach to 'practical.' I should be less competent in every way without such knowledge.

"6. I certainly do. If they are to be eliminated I do not know what should be retained."

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Dr. James B. Herrick, physician: "A progressive physician today *must* know physics, chemistry, physiology, physical chemistry, etc. Without the elements of mathematics such knowledge is impossible."

-Mr. Marquis Eaton, attorney: "These studies (algebra and geometry) tend, in my opinion, to develop the power of analysis, which power lies at the threshold of success in every profession, notably the legal profession."

Mr. James E. Otis, President, Western Trust and Savings Bank, "I consider the study of high school mathematics as a necessary part of a high school education. In so far as I am concerned, my knowledge of algebra, geometry and higher mathematics frequently enables me to analyze problems which come before me. It is the training of the young mind in the study of algebra which I consider of greatest importance and not the practical use he can make of the science in later life. In so far as geometry is concerned, questions are constantly arising where I find my knowledge of geometry most helpful. I feel so strongly on the subject that I should consider the dropping of algebra and gometry in our secondary schools as a very serious mistake"

Mr. S. M. Hastings, President, Computing Scales Company of America: "My personal business experience has taught me that mathematics, algebra and geometry are important, and in my opinion they should be retained in our schools. With a knowledge of these, one is better fitted to cope with the business problems.

"As we become a greater world power and our foreign business expands, the need of every possible mental equipment will be more and more in evidence."

Mr. C. A. Creider, Secretary to Edward B. Butler of Butler Brothers: "Anyone who has been able to compass the subjects of algebra and geometry is by very nature of his training equipped to comprehend a problem or to arrive at a solution thereof much more readily than the fellow who has not had the training referred to. In other words, even a private secretary, who might be expected to have very little to do with the principles of these two studies, finds it much easier to fill his position having gone through the mental exercise of study of these two subjects."

Mr. C. S. Cutting, attorney, Holt, Cutting and Sidley: "The study of high school mathematics was worth while to me for this reason, among others, that the cultivation of the habit of

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mathematical methods of thought not only fixed my knowledge of the so-called practical mathematics of the grammar school, but made all operations of like nature, whether strictly mathematical or otherwise, easier. . . . It is not usually possible to shirk work (as a student) in mathematics (it is therefore desirable in the course of study). . . . We use geometry in the examination of titles to real estate, in the investigation of plats and in many other relations where mensuration of both lines and angles must be considered. In my opinion, however, this is the smallest part of the benefit derived from the study of these subjects. . . . I believe that the emasculation of a literary college course by omitting the classics is an educational mistake which would be equaled by omitting the mathematics. My experience teaches me that the man who knows a few things well is better educated than the one who knows many things indifferently."

Mr. James K. Ingalls, President, Western Heater Despatch: "High school mathematics taught me system, to be accurate, to have confidence in my conclusions, and accustomed me to abstract reasoning."

Mr. Granger Farwell broker: "I employ algebraic and geometrical calculations in business and many times without knowing that I specifically do so."

Miss Harriet Vittum, social worker, says:

"2. Yes, I disliked it so heartily I needed to *have* to do it.

"6. Yes, as general mental discipline if not to fill specific needs."

Rev. James G. K. McClure President, McCormick Theological Seminary, "I am accustomed to say that the classics have done more to prepare me for my life than any other study or studies. The drill in Euclid at Yale was very disciplinary."

Rev. M. P. Boynton, Woodlawn Baptist Church: "The practical geometry that I learned in my father's carpenter shop, and which was based on the steel square of the workman, has been of greatest practical use to me. Though I had no occasion to use these rules for many years, I was delighted when in building my summer home, and needing the rules for cutting and fitting the rafters and other timbers to find that these principles which I actually worked out as a boy freely came back to me. I believe that this is nature's great law and that we retain only such knowledge as we are able to make real use of."

Dr. J. Clarence Webster, physician, says that in planning

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the education of a son or daughter he would not include algebra or geometry, "unless these subjects were directly related to their professional work. . . . I think they are as useless as Latin and Greek and should not be taught to the great majority."

A prominent clergyman of the city writes: "Even the admitted value of geometry in training the logical faculties has to be discounted because the faculty is there developed in a field entirely apart from any of the practical problems of life, and its general cultural value is therefore indirect and remote. This is not so much a matter of judgment on my part as a matter of practical experience. My judgment is that algebra and geometry are quite unnecessary as a part of *general education* and that for purposes of general culture other subjects are much more useful in the curriculum of secondary education. Yet it is perfectly clear that engineering and architecture, not to mention certain branches of physics and astronomy, absolutely require a knowledge of algebra and geometry.

"My daughter, now twenty-one years of age, had a distinct gift for languages and history. Mathematics of any kind were exceedingly difficult for her and even untiring industry and excessive efforts barely sufficed to secure a passing mark. Yet algebra was a required study and graduation from high school impossible without a reasonably satisfactory record in this study. She will never make any use of algebra and she has bitter memories connected with its study, together with a rankling sense of injustice in a system which requires a given standard in this useless subject and allows no substitutes in the requirements for graduation."

This is probably as representative a group of persons as could be selected. A larger group would not be likely to change results greatly. They are all busy men of affairs. That they should answer so fully is significant of the importance they attach to such matters. About 90 per cent answer favorably to the importance of mathematics in secondary schools, some of them emphatically so. This is an overwhelming majority. An election with such a majority would be called "a landslide." While there are many factors which may enter to make the opinion of a single individual, or even of a small minority, of doubtful value, great importance must be attached to the opinion of such a majority. The members of such a group cannot all be biased or prejudiced; they cannot all be out of date in such matters, or be unacquainted with the trend of affairs in

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the educational world. The fact that they are successful men precludes any such notion. Some of them are giants in the business world and in other fields—men to whom we look for leadership.

However, the opinion of a minority, or even of a single individual, is not a negligible matter. These frequently suggest important lines for improvement, or they raise an issue and put to the test things that have come to us through tradition. When we recognize a fallacy in the argument of an opponent we are reassured in the position we hold. Those who have opposed the teaching of mathematics in high schools—where they have expressed themselves beyond the mere answer "no"—seem to think of mathematics only as a tool. To them its only value seems to be the direct application in the sciences or in the doing of the world's work. This is a mistake, as is shown by the answers to questions one and five. Question one, which is considered as referring to cultural values, has an overwhelming majority in the affirmative; while question five, which represents the utility values, has a small negative majority. Evidently the direct application of mathematics to other fields is of secondary importance. The chief values are culture and mental discipline, training in logical and abstract thinking, the cultivation of the power of concentration, and the acquiring of speed and accuracy in our mental activities. However, this matter will be treated at greater length in the more complete report to be made later by this committee.

President Butler of Columbia University says in *Educational Review*, September, 1917: "No educational instruments have yet been found that, in disciplinary value, are equal to Greek, Latin, and mathematics. The descriptive and experimental sciences cannot do it—or at least they have not done it—and the same is true of the newer subjects of study that are humorously if roughly, classified together as 'unnatural sciences'—economics, sociology, and the like."

An investigation, as reported by Mr. Harris Hancock in *School and Society*, June 19, 1915, was carried out recently in Cincinnati. Of 105 prominent persons in the city, and 99 outside the city, consulted with reference to the question, "What course of study should be taken by a boy who is entering high school?" 167 answered that they would require mathematics, 18 would require either mathematics or the classics, and 12 would make mathematics elective. This experiment carried

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on with a larger group more widely scattered gives approximately the same majority in favor of mathematics as is shown in our experiment. The following came with the replies:

Hon. Chas. Theodore Greve, of the Cincinnati Law School: "I have specialized in history and economics, but they can never take the place of classics or mathematics. Both are essential and there can be no possible substitute for either. . . . These two subjects are the essential groundwork of education that is to be of value for any subsequent career, professional, scientific, business or mechanical."

Hon. Roscoe Pound, of the Harvard Law School: "The two things which appear to me to be required of secondary education are, linguistic training . . . and some sort of training which will form settled mental habits of accuracy and thoroughness during the student's formative period. I believe mathematics will achieve the latter result as nothing else may. Personally I never liked mathematics; but they were valuable, not for what I remembered, but because I was compelled to see that two and two make four, instead of presenting plausible arguments that it might be otherwise."

Mathematics is, however, an important study not for the boy alone but for the girl as well. Since the girls of today will be the mothers of tomorrow, and so will bear the greater share of responsibility in the education of the coming generation, for this reason, if for no other, algebra and geometry ought to be a part of the education of every girl.

Margaretta Tuttle, an author, and also of Cincinnati, says in *Good Housekeeping*, September, 1917, that the old line education, even though requiring effort that is not always pleasant, is best. "Will-power continues to be the great need of all who hope to grow and be of use. And it continues to develop only by use.

"Marianne hates solid geometry. Marianne's mother does not see why her daughter has to waste a whole year on something she can never by any possibility use. Marianne is literary. Oh, no! Literary ability and mathematical ability rarely go together. Marianne, who is eighteen, and who knows a little about the lives of writers and nothing at all about engineers, will tell you so. But all the same, after Marianne, by the sweat of her brow, has worked out these different problems, she will have formed the habit of not flinching from thinking things out—one of the most necessary habits for a literary person and for any woman.

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"Women do not always do it, nor men either. It is the thinking of things out that steadies the world. It is the confronting of a problem with the intent of solving it after you have seen both sides of it that makes you a real help in a world of unsolved problems. You cannot write a good story, short or long, without a problem in it that has to be thought out and then demonstrated. Many a literary person living a meager life on small success, unable to solve the problem of why it is so meager, needs a little mathematical training. Many a mother struggling with the problem of her child's food, and wishing she had taken dietetics instead of piano lessons, needs the mathematical touch —the ability first to recognize a problem when she sees it, then to attack it without worry, to bring to its solution all the like problems that have been previously solved, all the axioms and theorems that actually apply to it, and then to come to a conclusion and to stick to it because it has been demonstrated. *Quod erat demonstrandum!* The woman who has learned the full power of that phrase has learned to handle facts."

These testimonies and the results of these investigations make it evident that algebra and geometry are *not* so much rubbish to be thrown out at the back door as quickly as possible, as some would have us think. The number of persons who object to the requiring of mathematics in our high schools is relatively a small minority, which, in its efforts to be heard, sometimes makes a noise all out of proportion to its numbers. The professional, the business, and the industrial worlds, at least, demand for the present, and will demand for years to come, that algebra and geometry be retained as required studies in the secondary schools of our country; and this notwithstanding the efforts of educational theorists and would-be reformers to the contrary. Would it not be time and effort better spent if the destructionists were to aim at the perfecting of the subject matter, and to the improvement of its teaching?

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HOW SCHOOL GARDENS TEND TO DIRECT A NATURAL COURSE IN BOTANY.

By Genevieve Monsch,
Froebel School, Gary, Ind.

I speak of this as a natural course because, unlike most other courses in botany, this one seemed to have unfolded itself gradually from day to day so that the subject-matter as well as the sequence of the work were largely determined by the progress of the more practical outside garden work, and by the demand for information by the boys and girls who were engaged in the work. It certainly grew independently of other courses of study and of textbooks—for we used none whatsoever—and it certainly developed quite independently of the teacher, who, when she had planned a definite series of lessons on soils was switched unexpectedly to herbaceous perennials, annuals, etc., and, at a time when she was least expecting to take up the most difficult of all subjects, namely, plant processes, she suddenly found herself in the midst of such problems with the most wide-awake girls and boys carrying her still deeper and deeper into the discussions of plant-physiology until, lo and behold, they were quite ably dealing with questions of photosynthesis, digestion and assimilation—and the teacher had, in several instances at least, discovered, through the class, a much simpler approach to the subject than any that had ever been suggested before. The class was not required to write up any notes of their work, and except in the work connected with the morphology of the flower, no drawings were required. We used no textbooks and no reference books in class, although government bulletins, seed catalogs and garden guides were constantly in demand and in use.

The course as I have outlined it here was developed with a class of seventh grade girls and boys who came to me in separate sections for only ten weeks, at the very end of the school year. Thus, only fifty hours of class time was given to this course, although the individual members of the class were permitted to work in the garden at odd times—and they did find much time to work there, in large numbers daily, by giving up either a gymnasium or an auditorium or a lunch period, or by begging off from some more formal work.

The foundation of the course was work out of doors, frequently in the school gardens, but occasionally in our school park, and on two occasions in the adjoining swamps and woods.

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First Week.

A. Investigation of Gardens:
  I. How are they laid out?
  1. Bird's-eye view from school windows.
  2. Blue prints of whole school garden plot on wall.
  3. Blue prints of individual plots.
  4. Excursions into the garden.
  II. What do they contain?
  1. Hardy annuals—lettuce, portulaca, Mexican fire bush.
  2. Biennials—parsnip, carrots, etc.
  3. Perennials—Dutch bulls, honeysuckle, lilac, etc.
  III. What are they going to offer us?
  1. Individual plots (two), selected and accurately measured.
  2. Class cold-frames visited and discussed.
  3. Soil:
    a. Soil composition—straw, manure, lumps of clay, sand, rocks, sandstone, quartz, etc., decaying vegetable matter.
    b. Subsoil—sand.
    c. Moisture content.
    d. Compost-heap.
  4. Animals in soil.

B. Individual Vegetable Plots:
  I. Measured carefully.
  II. Diagram to scale.
  III. Individual selection of vegetables from seed catalogs.
  IV. Cultural directions studied for spacing rows in diagrams.

Note: Diagrams of individual plots must be completed at the end of the first week.

First Week.

During the first week of this course we did little outside garden work although we were kept more than busy with our investigations, our seed catalogs, our garden diagrams, etc., as shown by the outline for the first week's work. (By the way, these outlines were made at the close of each week while those made at the beginning have been long since discarded as useless.) The class encountered a steady downpour of rain on the very first day of the course, which, however, proved fortunate, inasmuch as it took us to the windows and to the general diagrams of the garden and to discussions of gardens in general *before* we started any actual garden work. I had planned an interesting series of work on soils for our first real excursion into the garden, but the class chased wildly to the beds of tulips, daffodils and hyacinths which were just beginning to peep above the ground. At least a dozen questions were eagerly asked (and answered) before these children showed any inclination to be turned aside. This gave me my cue, and I really found it the simplest matter in the world to explain annuals, biennials, perennials, etc., and to find them most anxiously searching in all directions for more and more types within the garden walls to illustrate each term. They asked for the names of everything and knitted their brows in order to help to fix them all in their

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memories and they repeated them to each other again and again The next day we had very little difficulty in getting the following outline from the class, although I purposely included again such new words as ampelopsis, clematis, etc., which they had forgotten overnight.

Blackboard Outline.

Our First Visit to the School Garden.

I. Hardy Annuals—lettuce, wild cucumber, Mexican fire bush, portulaca, morning-glory.
II. Biennials—parsley, parsnip, lunaria.
III. Perennials:
1. Woody perennials—rose, privet, hydrangea, lilac, willow, one peach tree.
2. Woody vines—honeysuckle, bitter sweet (celastrum), ampelopsis, wistaria, clematis, rose, Virginia creeper, etc.
3. Herbaceous perennials:
a. Bulbs—tulips, daffodils, hyacinths, etc.
b. Rootstocks, tubers, etc.—ferns, violets, lilies-of-the-valley, various weeds and peony, cannas and dasheens in cold-frames.

Note: Diagrams of individual plots must be accurately finished at end of first week.

Their vegetable plots were next selected and measured and careful diagrams made to scale, *after* they had each decided for themselves just what they were to grow. Seed catalogs were studied and were borrowed to be taken home to be discussed with the family, and the all-important matter of their lives became, for that week at least, a garden diagram to represent their individual tastes and the method of planting. By the end of the first week most of the diagrams were accurately made and our real work in the gardens was beginning. I am not going to discuss in this article the flower plots—for each pupil of course had two plots, each being about four by seventeen feet, one for vegetables and one for flowers. Everyone had to begin with his vegetable plot but just as soon as this was laid out and planted he could begin with his flower garden. There was no one in the class who did not finish both plots before school closed.

Second Week.

A. Restaking Individual Plots.
B. Preparation of Seed Bed:
I. Adding barnyard manure (why?).
II. Deep spading (why?).
III. Pulverizing with hoe and rake (why?).
IV. Add sand (why?).
C. Fertilizers:
I. Natural manures:
1. Animal fertilizers—bone meal, barnyard manure.
2. Green manures—legumes. Do all plants have tubercles on their roots?
II. Commercial fertilizers—from animals, plants or minerals:
1. Steamed bone (phosphoric acid).
2. Dried blood (nitrogen compound).
3. Wood ashes (potash).

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4. Ammonium sulphate (nitrogen compound).
5. German Kainit (potash).
6. Acid phosphate (phosphoric acid).

Note. There are usually only three most necessary ingredients that must be supplied: (a) nitrogen compounds; (b) potash; (c) phosphoric acid. One ton barnyard manure contains: Nitrogen compounds, 10 lbs.; potassium, 8 lbs.; phosphorus, 2 1-2 lbs.; lime, magnesia, etc.

III. Discussion of rotation of crops.

Note: Why is barnyard manure one of the very best fertilizers?

Second Week.

By the time these children had worked with seed catalogs and cultural directions for a few days, they became exceedingly familiar with such terms as annual, biennial, etc., and with tubers, bulbs (sets of onions), etc. Moreover, questions of soil (light soil, heavy soil, loose soil, loam, clay, etc.) were constantly arising, and fertilizers and soil covers were beginning to puzzle their little brains. They were grateful to have an hour indoors to clear up a great deal of this work towards the end of a delightful week in the garden which, however, had required heavy muscular work in the preparation of the soil for a seed bed. Some of these children had added more barnyard manure to their plots and all of them had spaded it under and pulverized their soil. In the laboratory we had kept large glass jars filled with different commercial fertilizers. These were not only labeled but they also contained the names of the principal ingredients which they could supply for the plant, and each member of the class was required to make a list such as you see under "Commercial Fertilizers" in the outline for the second week's work. In this way they were made to feel that the three most important ingredients to be supplied to the soil are nitrogen compounds, potash, and phosphoric acid—and the value of barnyard manure was forcibly brought out by the diagram which they made. Lime was also discussed, and green manures became of so much interest to these children that they were constantly sacrificing their beans and peas for the sake of a little research on their own part. I would like to say that this seventh grade class was allowed the use of the compound microscope on several occasions and that this was one. It was a matter of no little surprise to me to find that they could handle these instruments as skillfully as high school pupils, and that they could interpret what they saw just as well. Their curiosity, however, was keener and their spontaneity and enthusiasm much greater.

Third Week.

A. Planting Seeds According to Diagrams *Exactly*.
B. Work in Perennial Beds:

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I. Remove covers of leaves, straw, manure.
II. Tillage of perennial beds in the school park as well as in the garden. (Value of tillage?)

C. Germination of Vegetable Seeds:
I. Requirements for germination:
1. Air.
2. Water (daily).
3. Warmth.
4. Soil (?).
II. Observations connected with germination:
1. Some rows have germinated. Why?
2. Some rows have not germinated. Why not?
3. Seeds cause soil to crack. Cause?
4. Arch to hypocotyl (or none).
5. Cotyledons—one or two? Color? Size? Position?
6. Plumules.
7. Seed coats above or below the soil?
8. Cotyledons above or below the ground?
9. One seed coat or more?
10. Cotyledons shrivelling.
11. Cotyledons turning green.
12. Why do cotyledons shrivel? (Food in seed? Uses of food? Kinds of food, etc.)

Note: Child in the garden always includes "soil" as one of necessary requirements for germination. As far as he has been able to discover up to this point, it is, and that is the reason it has crept into this diagram.

Third Week.

This is the week when enthusiasm certainly does run high, and when the skillful teacher will keep it high, and see that it is quietly and unsuspectingly directed into the right channels. Their seeds are germinating, some of them at least, and the teacher must be sure to see that they are discovering, each for himself, the cracking of the soil, the arch to the hypocotyl, the cotyledons and plumules and seed coats and a hundred other things, in the height of their eagerness. She must be the spirit behind them that keeps them eagerly watching, and she must keep them puzzled and interested over a hundred things that are happening or not happening. "Why" should constantly be heard in the garden and if the child ever fails to ask it, the teacher must.

Fourth Week.

A. Seeds:
I. Structure of seed:
1. Seed-coats.
2. Food in seeds:
a. Starch or sugar.
b. Oils.
c. Proteids.
3. Embryo:
a. Root.
b. Stem.
c. One or two seed leaves.
d. Plumules.
II. Monocotyledons or dicotyledons.
III. Uses of food in seed:

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1. Growth.
2. Energy.
3. Repair.

Note: Continue observations in gardens and pigeonhole information as germination progresses.

Fourth Week.

During the fourth week we directed our discussions to the seed. These children had eagerly watched and helped hundreds of seeds to grow and were quite familiar by this time with the parts of the seeds. There remained only one thing more for the teacher to do; that was, to systematize their knowledge and to review or to add such technical terms as proteids, etc. Technical terms were avoided just as far as possible in this whole course. Since we used no text, it was easier to avoid mere terms, too. Instead of embryo, for instance, we used "baby plant in the seed." Instead of cotyledons, we used "seed leaves," and "first real leaves" instead of plumules.

Fifth Week.

Plant Processes:

A. Review Food Storage in Seeds and Uses of such Foods in Plants.
B. Name other Food Storage Places (roots, stems, leaves, flowers, bulbs, tubers, etc.)
C. Photosynthesis:
    I. Gross structure of leaf:
        1. Stalk.
        2. Blade:
            a. Green tissue.
            b. Skin.
            c. Veins.
    II. Experiment: Starch = $C+H_2O$.
    III. Experiment: Conduction.
    IV. Experiment: Solution (sugar and starch).
    V. Discussion: Conduction, assimilation, respiration, storage, transpiration, reproduction, death.
    VI. Experiment to show transpiration.

Fifth Week.

Now, you may wonder how we suddenly jumped from germination to photosynthesis but by good luck an accidental question directed our work along this line the first time I gave any kind of an organized garden course, and it fitted in so easily that I have put it right about here at other times. One of these lads one day accidentally discovered a huge plant growing in a ridiculously small pot of soil and he at once demanded to know "how such a little bit of soil could ever produce such a big plant?" It was a golden opportunity to discuss starch-making and other physiological processes. By weighing the plant as it stood in its pot (17 lbs.) and then by weighing a similar pot filled with soil but without a plant (12 lbs.), there was clearly a

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gain of five pounds of matter which could not possibly have come from the soil. Where could this extra gain have come from? Where indeed but from the water and the air! It is not difficult to show (by burning) that plants are largely composed of carbon (plus water); and by heating starch in a test-tube, that starch is carbon plus water, and so I found that it was not beyond the comprehension of these children to understand that green tissues in plants make starch out of the carbon in the carbon dioxide of the air and out of the water from the soil which the roots send up. Just a step further, and we had worked out the subjects of conduction, solution, digestion, assimilation, etc. I took great pains to keep this subject ever before their attention in one way or another until the very close of school and there were many opportunities for doing so—the cotyledons turning green and then dropping off *after* the plumules are able to manufacture starch; the storage of food in seeds, tubers, bulbs, tap roots, etc., the original source of food, and the kind of food stored up in their garden crops which they themselves were appropriating as a supply for their own bodies, the demand for increasing leaf-surface on the part of the plant, etc.

Sixth Week.

A. Where Do Seeds (and Fruits) Come From?
   1. Locate immature fruit and seeds in tulip, hyacinth, narcissus, violets, pansies, willow, lilac, fruit-blossoms, iris, sweet peas, bush-honeysuckle.
   2. Also find pollen boxes in each flower.

B. Morphology of Flowers:
   1. Seed case and seeds.
   2. Pollen boxes (and pollen).
   3. Petals.
   4. Sepals.

C. Functions of Each Part of Flower.

D. Analyze Flowers, as Many as Possible:
   1. Hyacinth.
   2. Tulip.
   3. Indian puccoon.
   4. Lupine or pea or locust.
   5. Geranium (wild or cultivated).
   6. Violet.
   7. Iris.

E. Discuss Pollination.

F. Discuss Fertilization in Flowers (Egg, Embryo, etc.).

(*To be Continued.*)

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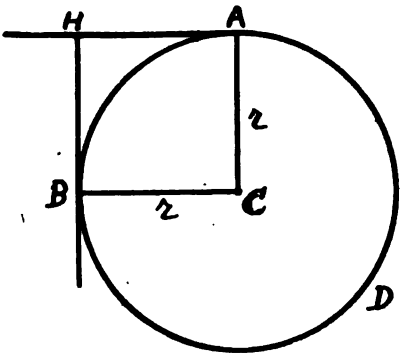
FORMULA FOR CENTRIFUGAL FORCE.

By ROSWELL PARISH,
Mechanic Arts High School, Boston, Retired.

Is it possible to satisfy a beginner that this formula is true without resorting to the method of limits? The following is submitted (with more or less of diffidence) with a view to criticism.



Let us suppose a mass m to be projected from A in the direction AH with a velocity v, and at the same time to be drawn toward C by a constant force f just sufficient to keep it in the circular path ABD. It is required to find the value of this centripetal force f and of the equal and opposite resistance—the centrifugal force.

Evidently the velocity will remain unchanged, since the force toward C acts always at right angles to the path and neither helps nor hinders the forward motion.

Now when the body starts from A it has motion in the direction AH. When it arrives at B, 90° from A, it has lost all motion in that direction and has acquired an equal amount in the direction HB, perpendicular to AH. In other words, the centripetal force has been employed equally in destroying the initial and producing the final motion of the mass m. The result is the same as if half that force $f/2$ acting through AH (or r) had done $mv^2/2$ units of work in destroying the original motion, and then the other half acting through HB (or r) had done the same amount of work in communicating the final motion. In either case, since as already proved $FS = MV^2/2$, $(f/2)r = mv^2/2$, whence $f = mv^2/r$.

The formula for acceleration follows readily, for
$f = ma = mv^2/r$, whence $a = v^2/r$.

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FORESTS AND LUMBERING REFERENCES

PREPARED BY W. M. GREGORY,
Normal School, Cleveland, Ohio.

The following list of references upon forests and lumbering has been prepared for the help of students and teachers of commercial and industrial geography, agriculture, and manual training. The list includes the sources that ought to be used when these subjects are well taught, and the star (*) indicates that the book has been used with junior high school students.

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THE GRAPH OF ax^2+bx+c.

BY J. L. PATTERSON,
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The solution of $ax^2+bx+c=0$ gives $x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}=\frac{-b}{2a}\pm\frac{\sqrt{b^2-4ac}}{2a}=\frac{-b}{2a}\pm k$, say. It is evident from the latter form that $\frac{-b}{2a}$ is the *axis* of the graph and if $\frac{-b}{2a}$ be substituted for x in the equation $ax^2+bx+c=y$, the value of y resulting will be the *lowest* point of the graph. (If the first term is negative, the value of y will be the *highest* point of the graph.) The point in which the graph cuts the axis of Y may be found, as usual, by making $x=0$ and the symmetrical point is at once determined. Thus we know the *axis*, the lowest (or highest) point and two other points, which will give the graph roughly by a minute's work. If the graph cuts the axis of X (that is, if there are real roots, not equal), two other points are readily determined by the solution of the equation.

Take for example, $2x^2-5x+8=0$. $x=\frac{-b}{2a}\pm k=\frac{5}{4}\pm k$.

$\therefore x=\frac{5}{4}$ is the axis and if $\frac{5}{4}$ be substituted for x in $2x^2-5x+8=y$, $y=4\frac{7}{8}$, the lowest point. Again, if $x=0$, $y=8$ and the opposite symmetrical point is $\frac{5}{4}$ to the right of the axis.

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A METHOD OF TEACHING IONIZATION.

By Leroy F. Swift,
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Did you ever succeed in teaching a class ionization? How often do you receive the answer, "Ionization is the breaking up of the molecules of a substance upon the passage of a current of electricity through the solution"? *Why*? Is your method of approaching this subject sane and logical?

Most introductions to the subject begin with experiments showing that certain solutions conduct the electric current. What does a boy see in such an experiment? *A most fascinating electrical experiment.* What impression of ionization can he get from this experiment? Electricity, it is true, is a point of contact with his previous knowledge, and the only one, but its inherent fascination and the fact that the desired results are invisible—explained only by theory—ought to make us look for a better introductory experiment for this topic.

The existence of ions can be proved more directly by a series of experiments with copper salts. Make saturated solutions of cupric bromide, cupric chloride, cupric nitrate, and cupric sulphate. Note the color of each carefully. They are all different and very similar to the crystallized salt—dark brown, green, dark blue, and blue, respectively. These are the colors of the molecules, for they are the colors of the masses. Now dilute each of these solutions by pouring a small quantity into a large volume of water. The four solutions now have the same blue color. What has happened? They must contain something in common. What? Copper. Yes, but in what form? Evidently not the insoluble, solid copper. Again, the color indicates that the copper in these solutions is in a different form than in the saturated solutions. In the latter, the smallest particle is the molecule of the salt—the copper bromide molecule for instance. The copper, there, is an inherent part of the molecule. Diluting these solutions with water separates the copper from the bromine. The copper, in this new form, since it imparts a bluish color to the solutions, is blue. The copper in this new form is called the copper ion, the bromine, the bromine ion, etc. The separation of the molecules into ions, by the water or other dissociating liquids, is called ionization or electrolytic dissociation.

The hydrogen ion of acids and the hydroxyl ion of bases may

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be shown by treating dilute solutions of either with the proper indicator—litmus, methyl orange, or phenolphthalein.

After using the above experiments to show the presence of the particles called ions, present the more difficult physical evidence for ionization—conductivity, rise of boiling points, depression of the freezing points, osmotic pressure, and electrolysis.

The conductivity experiments are now in order, for we wish the terms electrolyte and nonelectrolyte, and more concise definitions of ions and ionization. A solution that will show directly the atoms ionized is preferable. With platinum or carbon electrodes, in series with an incandescent lamp, pass a current of the proper strength through a solution of cupric bromide. A deposit of copper forms on the negative electrode, and bromine appears at the positive electrode. Repeat, using other solutions—salts, acids, and bases. In all cases the filament of the lamp glows, showing conductivity. Now use solutions of sugar, alcohol, and distilled water. These solutions, since the filament does not glow, are nonconductors or nonelectrolytes. Now present the theory. The latter solutions do not conduct the current because their molecules do not break up into ions. The ions of the former act like bodies charged with electricity—a static charge. They are attracted or repelled by the electrodes. The copper ion, for instance, always goes to the same electrode—the negative one. Hence the copper ion is the copper atom bearing a positive charge of electricity. The bromine ion must, then, bear a negative charge. The nonconducting class of solutions allows no current to flow; therefore, they have no such charged particles. A more complete definition of the ion, then, is an atom, or a group of atoms acting like a single atom, bearing a charge of electricity. The influence of this charge is responsible for the new properties. Further study of such experiments shows that the molecules of the electrolytes break up, on solution, into two parts, one carrying a positive charge of electricity, and the other an equivalent charge of negative electricity.

All of these solutions which conduct the electric current—electrolytes—show, when compared with nonelectrolytes of equivalent molecular concentration, a rise in the osmotic pressure and the boiling points of just twice as much as the nonelectrolytes. Again, the freezing points of solutions of the electrolytes show a depression twice as great as that of the non-

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electrolytes of equivalent concentration. Why? Explain this by means of the kinetic theory. Pressures and also boiling points and freezing points depend on the number of impacts per second—the number of molecules striking per second. Since these pressure changes in the electrolytes are twice as great as those in the nonelectrolytes, the solutions of the former must contain twice as many particles. Since the molecular concentration is the same, each contains the same number of molecules. Hence each molecule of the electrolyte must have broken up, on solution, into two parts. This would account for the increases in the pressures noted in the solutions called electrolytes.

Ionization is greater in dilute solutions. Ostwald gives an experiment that shows this very clearly. Add a few drops of ammonium hydroxide to an alcoholic solution of phenolphthalein. There is no evidence of the hydroxyl ion. Add water slowly, and the characteristic color soon appears. (The color will disappear if enough alcohol is added.) Since this color reaction is a test for the hydroxyl ion, hydroxyl ions are more abundant in dilute solutions.

I often feel that we do not emphasize the ionic theory enough to make it of real use in our teaching. I believe that we should write more ionic equations and make insistent use of its teachings in neutralization and electrolysis.

In many of these suggestions I have only indicated a method of procedure, but I trust that I have made clear the fact that we must and can make a more constant application of the psychological principle of apperception.

REPLY TO "ELIMINATOR OF WASTE IN THE HIGH SCHOOL."

By Jessie D. Brakensiek,
High School, Quincy, Ill.

I have read with much interest an article in the November, 1917, number of School Science and Mathematics, entitled, "Chemistry as an Eliminator of Waste in the High School." I feel that the author is so greatly in error in many of the things he says against other subjects in the curriculum that he needs to be corrected. His main attack is directed against geometry, Latin, and modern languages; his plea is made in behalf of chemistry. I do not wish to attack chemistry, for I believe that it is a subject worthy of a prominent place in the curriculum, and

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that the writer, carried away by his own enthusiasm, has merely claimed too much for his subject. Had he not recommended it as a panacea, one would be more ready to accept it for its real worth. I feel that a plea should be made for the other subjects which he has chosen to attack. Let us take the author's own line of argument and see how it may be applied to the despised geometry and language.

"Educators agree that there are five main types of learning: (1) Acquiring motor skill. (2) Associating symbols and meanings. (3) Acquiring skill in reflective thinking. (4) Acquiring habits of enjoyment. (5) Acquiring skill in expression."

I shall endeavor to show that geometry and language are not so lacking in these virtues as our author would have us believe, and I shall not throw mud at the subject of chemistry in order to prove my point.

First, *acquiring motor skill.* The author evidently has forgotten that a great deal of construction work is given in geometry, involving the use of ruler, compass, and pencil. Drawing on blackboard and paper is an everyday occurrence. That motor dexterity is actually taught is proved by a comparison of drawings made by beginners in a geometry course with those made by more advanced pupils. Certainly the evidence which can be produced defending geometry on this score is fully as conclusive to an impartial observer as the breakage charges of an average chemistry student. If anyone thinks that geometry offers little training in acquiring motor skill, let him try to make a drawing of the "devil's coffin," or to construct models of the regular polyhedrons, or to inscribe a regular pentadecagon in a circle and actually get a fifteen-sided figure. As for the languages, no plea can be made under this head. Their value lies in other directions.

Second, *associating symbols and meanings.* Has the author forgotten that geometry is full of symbols, that the laws of mensuration are here developed, and then put into formulas for ready reference and use? As he has already said in regard to chemistry, I shall say in regard to geometry: "Witness the multiplicity of symbols and formulae," and I shall be fully as correct as he. When it comes to the case of languages, let me quote again. In reference to associating symbols and meanings, he says: "It has been stated that this type of learning is furnished most by modern languages." This idea he has wisely not attempted to disprove. That the word, modern, can justly

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be eliminated from the quotation any fair-minded person must admit.

Third, *acquiring skill in reflective thinking.* The writer admits that training in reflective thinking is the real value of geometry, but says that "this end can be just as well served by other courses." Later he says, "The training in thinking acquired in geometry is generally found to be of no use in other subjects requiring thought." Suppose we admit the truth of this statement. Will we not have to explain how training acquired in chemistry will be of use in other subjects? Why will thinking "about the behavior of gases, about evaporation, about ignition, about temperature, about solution, about concentration effects, etc.," be a more beneficial training than thinking about the congruence of triangles, the use of geometric figures in construction and in design, or the conic sections? Why are the subjects that the author suggests more provocative of thought than the ones I suggest? And why will training in thinking acquired in chemistry pass over so readily into some other unconnected field of thought, if the training offered by geometry will be of little or no avail? If I admit that the training in thinking acquired in geometry will serve only in the mathematical field, will he not also have to admit that the training acquired in chemistry will serve only in the scientific field?

Why does he say nothing of the value of languages in training pupils to think? Does he not know that there is no work in school so difficult for the scatter-brained as languages, that success in language work depends upon clear and logical thinking?

Fourth, *acquiring habits of enjoyment.* Here again let me quote: "Training for the enjoyment of leisure time is one of the ultimate ends of education." Agreed. I hope, however, that he does not mean to argue here that chemistry surpasses languages in this respect, with the testimony of the educated the world over so overwhelmingly in favor of the classics. How many read chemistry for pleasure? Any more, think you, than get pleasure out of their geometry? Do your meals taste any better for knowing that now you are eating proteid and carbohydrates instead of meat and bread? Does H_2O slack your thirst any better than a draught from the fountain which sets you to repeating, "O fons Bandusiae, splendidior vitro"? Does an article on soap-making, say, give you more enjoyment than a study of a magnificent building whose architecture is made

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intelligible through the study of classical lore and of geometry? To my mind, language has much the best of the argument here, and geometry can at least hold its own with chemistry.

Fifth, *skill in expression*. Here the writer says: "I have resorted to the following scheme." Is not that a confession that chemistry is not wonderfully adapted to developing skill in expression? Does a Latin teacher have to "resort to a scheme" to secure this end? If the writer thinks that translation work does not foster skill in expression, let him try to give a vigorous translation of an oration against Cataline. By the time he has accomplished it he will have a wholesome respect for Cicero's command of language, for he will find his own vocabulary taxed to the utmost. In the case of geometry, I would not claim for it greater possibilities in developing skill of expression than I would for chemistry—nor less. In both, the field for expression is limited to a clear, concise statement of fact.

In closing, the author makes a plea for the practical worth of chemistry. I am perfectly willing to concede that he is right I am glad the chemist does so much for the farmer, and the manufacturer, and for all of us by making the world a healthful and pleasant place of abode. I thank him for his gorgeous dyes, his cleansing soap, and even for his powder and explosives, now that the main business of this country is war I honor him for his worthy achievements. But are these of more worth than the dams, which furnish power and make possible the reclamation of the desert, or than the Panama Canal? Are these more valuable than the building of bridges and ships, of churches and skyscrapers, of schools and homes, which need the principles of geometry for their successful design and construction? It is true that the majority of those who take geometry will never be engineers or architects Is it not also true that many take chemistry who will never be chemists? Shall we teach geometry only to those who will need it? And, if so, how are we to select them? Are we so omniscient that we can select the chosen few who are to be our engineers and architects? And, if we could, would we be wise to do so? Bah, the idea smacks of German efficiency, of which the world has already had an overdose. Why not also acknowledge the debt we owe to Latin and other languages? The author would do well to peruse Miss Frances Sabin's book, *The Relation of Latin to Practical Life*, particularly pages 58 to 62, and most particularly page 61. For fear he may not do so, let me reproduce the last three lines of page 61:

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"Professor Bauer, the distinguished chemist of Vienna, once said: 'Give me a student who has been taught his Latin grammar and I will answer for his chemistry.'" Let the writer try this test on his own class. See if those who have studied their Latin the most diligently are not as a rule good in their chemistry.

Moreover, the author is himself under a greater debt to the classics than he realizes. His article abounds in Latin English and in some English Latin. Witness, he says formulae, when he might have gotten further from the despised subject by saying formulas. How can the author be a really up-to-date chemist without a knowledge of French and German? I have been told that much which a chemist should know of French and German research is not found in translation.

Through enthusiasm for one's own subject, one must not fall into the error of overlooking the worth of another's. All are good. Some appeal to one, some to another. The public schools should make their appeal to all. Therefore, may chemistry flourish, but permit geometry and language to occupy their rightful place. Live and let live.

HINTS FOR COLLECTING BOTANICAL AND ZOOLOGICAL MATERIAL.

By John L. Dahl,
Highland Park, Mich.

Botanical and zoological material can easily be collected and kept on hand for use by schools in any locality, rural and metropolitan alike, such collections making teacher and class independent of season, imperfect illustrations, and distant supply houses. This being the case, less stress should be laid on so-called museum specimens, and greater stress on material available at the threshhold of almost every school. Many additions can be made by individual teachers to the suggestions given below.

Botanical Material.

Dry fruits et al. as follows: ash, elm, milkweed, dandelion, maple (several forms), ailanthus, catalpa, cucumber tree, chestnut burrs, horse-chestnut burrs; pine cones and those of other evergreens; acorns; various cultivated forms as morning-glory, balsam, poppy, nasturtium, etc.; seeds of all kinds from several successive years (label according to year collected, as 1915-1916-1917-1918), excellent for trying viability tests; desiccated twigs to show morphology of tendrils, spines, thorns,

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etc., dried specimens of all unusual conditions in nature, such as cross sections to show knots in wood, grafted stems, characteristics of bark of all available trees, etc.; cornstalks.[1]

Fleshy fruits et al. (these may be preserved in four per cent formalin as a rule): thorn apples, osage orange, bean pods and pea pods, rose hips, cucumbers whole and in section, boiled corn cobs for extracting easily the embryo from the "seed"; stages in the development of the apple fruit, for example, from the bud to the blossom and the very small fruit, then various stages in the development of the fruit, and sections of the mature fruit; cultivated fruits of all kinds, such as cherry, plum, peach, currant, strawberry, etc.; specimens of seedlings in various stages of development; fleshy roots, whole and in section.

Rare specimens (if fleshy, preserved in formalin): pitcher plants; petals of the water lily to show the transition from petal to stamen structures; pistils of the double cherry blossom to show the leaf-like character of the pistil; sprouted potato showing the development of small potatoes from the parent; etc.

Zoological Material.

Special equipment, of course, is necessary to take care of living material in the classroom. For preserved material the hints for collecting botanical materials will suggest what sort of zoological specimens to collect (four per cent formalin may be used as a rule for preserving proper zoological material).

Several stages in the life of the grasshopper, showing incomplete metamorphosis; abundance of crayfish material, showing varying sizes, also female with eggs attached; dried material, showing metamorphosis of various kinds of insects; insect collections, showing mimicry, protective resemblance, etc.; earthworms; habitations of various hymenoptera, made of paper, mud, leaf, and stem tissues; cocoons of various kinds; collections of birds' eggs and stuffed birds (and other animals) obtained under proper circumstances, etc., etc.

Methods of Preservation.

Mice, insects, and dust are factors destructive of biological material but are easily guarded against. Ordinary preserving jars are cheap, transparent, easily stored, and mouse-and-dust proof. No rubber rings should be used for dry material, as a circulation of air and desiccation is desirable. Material preserved in formalin should be made air-tight to guard against evaporation.

[1] Many specimens may be preserved both in a dry and a fleshy condition.

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A SCIENCE CLUB IN A HIGH SCHOOL.

By Louis C. Feldmann,
University of Wisconsin, Madison, Wis.

Every high school in which seventy-five or more pupils are enrolled ought to have a science club. While attending high school the boy passes through what G. Stanley Hall calls "The Gang Age." It is during this period that much permanent damage to the boy's character can be done, for at this time he chooses his associates. These will exert their good or bad influence over him as the case may be. On the make-up of the gang and its moral standard will depend the developing or the suppressing of such traits as good-fellowship and a desire to do right. Since the boy's later character depends to such an extent on his associates, the greatest aid that can be given him is the choosing of proper companions. The club with its selected membership exercises this function.

For the girl such a club is no less important; first of all, on account of the influence for good that she, under proper guidance, can exert on the boys, her fellow members. Then as for herself this association will develop in her the spirit of cooperation. This last-mentioned trait was formerly considered as desirable for men only, but with the growing complexity of economic life this spirit is no less essential for women.

Aside from the power of developing character which such a club can be made to exercise, both boys and girls will have instilled in them a love for nature and the great outdoors. These two features, if properly rooted, will remain with them throughout life. They will be no mean sources of pleasure and health during their active years, and an enjoyable pastime for old age. If education is a preparation for life, then this club is a necessary part of education.

We have noticed the necessity of a club for the boy to carry his primitive instincts into worthy channels. The girl needs a club to round out her character and aid her rapidly developing womanhood. The natural inclinations of both call for it; as well as the need of making wholesome recreation a hobby to be indulged in throughout life. But on whom falls the lot of organizing and directing such an undertaking? It is extra-curricular and yet highly educational. I should answer that it is the biology teacher's duty, for his field is attractive enough to arouse the dormant interests of the pupils. Further, the biology teacher will not only feel as though he has accomplished some

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educational work, but he will draw around himself a circle of interested boys and girls who will be able to discuss intelligently with him his special problems.

There is another good result which the teacher can consider as having accomplished. I here refer to the community spirit of the boys and girls. After a successful year as a member of a biology club, the interest in parks, flowers, and the general beauty of the surroundings will be appreciated far more. They will make attempts to keep the neighborhood neat, and if possible they will cultivate plants or shrubbery in bare places.

Now by organizing and directing I do not mean that the teacher should immediately after entering upon his duties send a notice to the assembly room stating that a meeting will be held at such a time for the purpose of forming a science club. Let the teacher first be successful in his classroom, and then after he has created the proper spirit in his students let them at his suggestion form a club. The official work of such a club ought to be in the hands of the students, except perhaps the position of critic. This the teacher could advantageously fill, for it would give him a place from which he could properly guide the actions of the club without making it seem as though he were controlling the activities, and thus kill the interest of the members.

To provide suitable programs in order to keep up the interest and induce proper activities on the part of the members is always a serious problem. On the nature of the program presented will depend the success and life of the club.

Various types of programs can be undertaken. One of these is to provide each member with a copy of a certain book, and then take up one chapter at each meeting and discuss it. As an aid to the discussion certain pupils can be asked to prepare short papers on certain phases of the subjects taken up in the chapter. Personally, I see no interest in such a meeting for our high school pupils. To them this would merely be another class with all the accompanying drudgery.

A more interesting program would be to study natural objects in their proper environment. This would mean field trips with the accompanying joys for the pupils. Of course these trips could be undertaken only during the fall and spring. During the winter other activities would have to be indulged in, and I think it would be well worth the while of the students if during the trips in the fall they were to pick up and preserve certain

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objects that they might happen upon, and then during the winter months study and discuss them. If a museum is to be found in the city, several meetings could profitably be held there. Then, too, programs could be arranged by having members give papers; talks, often illustrated, by members of the faculty; and addresses by outsiders who are experts in their own lines.

In the winter months, if the interest begins to fail, the scope of the club could properly be widened somewhat so as to include the fields of physics, chemistry, and geography to some extent. A feature of a few programs could be the visiting of some of the local industrial plants. This ought to be both profitable and enjoyable. Often a whole program could be taken up with one subject. At some meeting, for example, certain students could present the subject of carbonic acid. A tank of gas could be bought, and many freezing experiments could be performed and their biological significance pointed out.

Membership is rather a delicate proposition, for if the rules are too stringent no students will join; and, on the other hand, if too loose the members will lose interest and gradually withdraw. Certain requirements ought, however, to be insisted on, and among these are (1) a mark of 85 in one subject, (2) an interest in science, (3) a readiness to attend all the meetings, and (4) a willingness to take part in the programs when called upon.

The dues ought to be fifteen or twenty-five cents a semester, which will be more than enough to meet all ordinary expenses and pay for one or two sociable events to be arranged for during the school year to break the monotony of a too scientific atmosphere.

ANNOUNCEMENT FROM THE UNIVERSITY OF MICHIGAN.

INTRODUCTORY SCIENCE—One-half or one unit. Instruction in Introductory Science should precede all other courses in science and should preferably be given in the ninth grade.

The aim of this course should be to enable the student to interpret his environment and his relation to it. Teachers of Introductory Science are expected to give instruction also in one of the other sciences and to have had adequate preparation in one physical and one biological science. The ground to be covered by the course should be largely determined by local conditions.

A committee of representatives from the Education and the Science men of the University of Michigan has been appointed to draw up a statement of the preparation advised for teachers of general science.

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RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.

University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE PRESENT OPPORTUNITY IN CHEMISTRY.[1]

By Roger Adams,[2]

Assistant Professor of Organic Chemistry, University of Illinois.

A few years ago the public in this country scarcely knew what chemistry or what a chemist was. When this war started, however, a change suddenly took place. The chemist is now one of the most significant individuals in the majority of manufacturing plants, as well as of the most vital importance to the war. In England at Oxford University the study of chemistry used to be known popularly as the "Study of the Stinks," but now this science at that same university is certainly being shown its due respect.

I believe that the present opportunity of the chemist may best be pointed out to you by reviewing briefly the chemical development made in this country by the American chemists since the summer of 1914. It is needless to mention what a monopoly Germany had on chemicals before the war started, a monopoly not only in organic chemicals, but to a considerable extent in inorganic chemicals. As soon as the supply was cut off it was not a difficult matter for American manufacturers to increase the output of most of those substances which had already been manufactured, and develop the processes for other inorganic chemicals of a similar nature, so that within a year most of the inorganic substances purchasable before the war could be procured in this country. It was more difficult, however, to fill

[1]Address delivered before the High School Conference at the University of Illinois, November 23, 1917.

[2]Dr. Adams has taken a prominent part in the effort to meet the American demand for organic chemicals whose supply has been cut off by the war. He has entire charge of the commercial manufacture of organic chemicals at the University of Illinois and is a member of a committee appointed by the American Chemical Society to arrange for cooperation among the large institutions in supplying organic compounds to educational and technical laboratories. He is also a member of a committee authorized by the National Council of Defense to consider problems in connection with organic chemicals and synthetic drugs.

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the increased demand for sulphuric and nitric acids which were most urgently needed in enormous amounts for the manufacture of explosives. Few people realize the large quantities of sulphuric acid needed in a country like the United States; in fact it has often been said that the civilization of a nation can be told by its output of this acid. In spite of Germany's prestige in chemistry, it was not more than ten years ago that the Badische Anilin & Soda Fabrik paid a very large sum of money to American manufacturers to find out the best apparatus for the making of sulphuric acid. The large increase in the production of nitric acid involved more complications, for the salt peter necessary had to be imported from Chile. Fortunately, this importation could be increased in a comparatively short time until the output of nitric acid was large enough to supply the demand. With the entrance of the United States into the war, the Government considered the problem of nitric acid much more seriously because it was necessary to rely entirely upon Chile for the raw materials needed for producing this acid. If Germany had not solved the problem of synthesizing nitric acid without the use of Chile salt peter, she could not have continued the war for a year with the supply of materials on hand in that country in 1914. Last April a committee of prominent American chemists was appointed to investigate the situation in the United States and to make recommendations to Congress. These recommendations were passed, and $35,000,000 was appropriated for purchasing a reserve supply of sodium nitrate, while $20,000,000 was set aside for the development of the general problems of fixation of nitrogen from the air. Of these fixation methods, there are three which have been used commercially in the European countries up to the present time: the arc process of combining directly nitrogen and oxygen to form the oxides of nitrogen; the cyanamide process consisting of a direct combination of calcium carbide and nitrogen to form calcium cyanamide; the Haber process, a direct combination of nitrogen and hydrogen in the presence of a catalyzer to form ammonia. By the first process, nitrates can be formed by absorbing the oxides of nitrogen in alkali. In the second, the calcium cyanamide is treated with steam to yield ammonia, which can then be oxidized quantitatively to nitric acid in the presence of air and a catalytic agent. In the same way the ammonia obtained in the Haber process may be converted to nitric acid. The first method is practicable only

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where a large amount of water power is available, consequently the latter two are those now being used in Germany. The General Chemical Company of this country nearly five years ago foresaw the necessity of synthesizing nitric acid from the air, and set their chemical experts to work on the problem. A process was developed which is now ready to be put into commercial operation, a process far superior to any that has been used in Germany or other countries. It consists in making ammonia, then oxidizing it to the acid. Although similar to the Haber process in that ammonia is produced by the direct combination of nitrogen and hydrogen in the presence of a catalyzer, it has the distinct advantages of using much lower temperatures, obtaining double the yields, and involving simpler mechanical apparatus. Of the $20,000,000 appropriated, the committee recommended that $3,500,000 be devoted to a plant to be erected in Sheffield, Ala., capable of producing 60,000 pounds of ammonia per day by the General Chemical Company's process and of converting this ammonia to nitric acid. Much smaller sums were set aside for the further study of other methods, excluding the arc method, which seemed impracticable at present. The most promising of these is that developed by Professor Bucher of Brown University during the last ten years, consisting of the reaction of sodium carbonate, coal, and nitrogen in the presence of iron as a catalyzer to form sodium cyanide, which by boiling with caustic soda gives ammonia and sodium formate. The ammonia can then be oxidized to nitric acid. The prospects are bright, therefore, that within a year the United States will be independent of foreign lands for their nitric acid.

Of the other inorganic chemicals, the lack of potassium salts was most seriously felt. Formerly, these had been imported almost exclusively from the Stassfurt beds of Germany, so that to supply the needs of the United States it became necessary to seek other sources. The kelp industry developed to an enormous extent, especially along the California coast; the extraction of potassium from alunite and other potassium-containing silicates met with more or less success; the extraction from beet sugar residues became a large business; the extraction from various natural brines and salts increased remarkably. Searles Lake in California alone is said to contain ten million tons of potassium salts, and the process of separation from the other salts is already a practical proposition. Finally, many plants

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for the extraction of potassium from wood ashes have been started, and in the Middle Western States huge amounts of corn cobs are burned daily for the large percentage of potassium that the ashes contain. To show the marked increase in the potassium industry, a few figures may be given. In 1915, the output of the various potassium compounds corresponded to a thousand tons of potassium oxide; in 1916 to ten thousand tons of potassium oxide; and the indications are that in 1917 the output will correspond to between fifteen thousand and twenty thousand tons. About forty per cent has come from the natural salts and brines, forty per cent from kelp, and twenty per cent from the other sources mentioned above. Thus the potassium difficulty is being satisfactorily solved.

Although much smaller in volume, the lack of an organic chemical industry was much more keenly felt by the general public. When a man's new black overcoat or a lady's black spring hat turned green in the course of a few weeks, that particular person began to realize that something should be done in regard to the dyestuff industry. In the same way, when thousands of persons could not purchase the medicinals they formerly used, these individuals began to feel that this country needed something more than a chain of drug stores. The organic chemicals may be divided into four groups, explosives, dyes, drugs and photographical developers, and fancy organic chemicals.

It is hardly necessary to mention the explosive industry. It was a strong one in this country before the war, and a comparison of the exports in 1914 with those of 1917 will serve to make one understand how rapidly it has expanded. In 1914, $6,000,000 worth were exported; in 1917, the figure will reach $1,240,000,000.

As for the dyes, the seeming slowness in their manufacture during the first year of the war may be excused when it is realized that the most fundamental substances, as well as the intermediate compounds, had to be manufactured before the finished products could be made. Germany had such a complete monopoly in this line of chemicals that the commonest substances were not produced in this country. When it became necessary, however, to develop this industry, which consisted before the war of five American concerns of comparatively small size that did some manufacturing but were for the most part importers of foreign dyestuffs, the manufacturers came to the front.

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At present, there are 150 firms producing either intermediate products or finished dyes, and of these at least fifteen are very large corporations. Already, about eighty per cent of all the dyestuffs which were imported before the war are now being manufactured in this country, and it is probable that half of the remaining twenty per cent will be on the market within the next year. The final ten per cent are very complex in nature, difficult to prepare, and needed only in small amounts. When it is brought to one's attention that for some of the common cotton dyes it requires more than twenty distinct processes in order to get the finished product, it is remarkable that the development has been as rapid as it has. It is true that high prices still persist, so that only the more expensive goods contain the better dyes, but this is simply because the manufacturer has invested large amounts of money, and as long as possible intends to make a big profit. Moreover, he prefers to work out at this time the preparation of new dyestuffs rather than spend his energy in developing to a greater extent the ones which he has already produced successfully in a commercial way. In 1913, $350,000 worth of dyes were made in this country; in 1917, $12,000,000 worth, and of this $12,000,000 worth, a very appreciable proportion has been exported. Last July alone, $500,000 worth were shipped abroad, chiefly to Argentine, Brazil, Japan, and British India.

One often hears it asked why American manufacturers did not enter this field before the war. The reply has been that it was due to the fact that we did not have good chemists in this country. That is a great mistake. The dye industry was not taken up for two reasons. First, no really large concern cared to go into this work, and smaller concerns were unable to compete with the German industrial methods. One specific example may be cited. About six or eight years ago, a concern in the East built a $200,000 plant for the production of aniline. At that time, aniline sold for twelve cents a pound and these particular manufacturers were able to produce it at 11 cents. Not long after their product was on the market, the imported material suddenly dropped to between nine cents and ten cents, and upon investigation it was shown that the German manufacturers were selling below cost. This was continued for nearly a year and a half until it was necessary for the American dealers to drop the business. About three months after that date the price of the imported material rose to thirteen cents a pound.

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The question as to why a larger manufacturer did not take up the work may be easily answered. Although the business was extremely important, it was not large enough to attract the American investor, because the labor and experimentation costs were great, and the returns would have been comparatively small, particularly on account of the keen competition which was sure to come from Germany. The following illustration will serve to bring out this point. All of the various color industries in Germany together manufactured over twelve hundred products and controlled probably eighty per cent of the world's markets. They paid in 1913 dividends to the amount of $13,000,000. In the same year the Ford Motor Car Company, which produced only one article, earned four times the amount of all these German color industries together, and paid at the same time three times the wages. Many more instances of this same kind might be given. The dye industry in this country is now here to stay, however. Not long ago I was told by the head of a big factory that they were producing many of the chemicals which were needed in very large amounts at a cost thirty per cent to forty per cent below what these substances sold for before the war, in spite of the fact that their raw materials were much more expensive. With a reasonable protection by the United States Government, the indications are that the American dye industry in the next decade will become second to none in the world.

The photographic developers have gradually been manufactured at the same time as the dyestuffs, so I will pass over this interesting group of substances and speak briefly of the drugs. Even before the summer of 1914 this country produced and exported large amounts of natural medicinals, substances extracted from plants, as quinine, strychnine, etc. But comparatively few synthetic drugs, those made up in the laboratory from simple organic substances, were produced in this country. At the present time, however, practically all the common ones are made and even exported in large quantities. The synthetic drug industry is a much newer one than the dyestuff, and many of the important drugs are still under the patent laws, and these patents are held chiefly by alien enemies. Since some of these substances are of extreme importance, the Government, a short time ago, passed a bill which would allow a reliable American manufacturer to obtain a license from the Federal Trade Commission to produce these substances provided

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he pay into the United States Treasury five per cent of the gross proceeds from his sales. This arrangement is to proceed until a year after the war is completed, six months from which time the patentee must sue the American dealer for his royalty. A court is then to decide whether the five per cent is large enough or too large, and the exact amount to be paid to the patentee will be settled. This bill, however, does not suit the American concerns, and a number of the larger ones have been unwilling to take up the manufacture of these patented drugs under such conditions. The American Government is willing to license more than one concern for the manufacture of these drugs, and therefore there will be competition, not only at the present time, but even keener competition with the German producers after the war. Although the bill has been passed for five or six weeks, comparatively few applications for licenses have been made, and many of these have come from concerns controlled by German capital. A few American manufacturers will no doubt undertake the production of certain of these patented drugs for which the demand is extremely large and where the indications are that the necessary investments will be paid for and big profits made before the war is over. In this group may be mentioned especially salvarsan, needed so extensively in the army, and novocaine, a local anaesthetic of the greatest value. There were some hundred or more other drugs manufactured almost exclusively in Germany and sold in this country before the war which had only a very specific use and consequently for the most part only small sales. Many of these are still under the patent laws. The remainder are not, but it will be a long time before American concerns will undertake the synthesis of these substances. The demand is small, the manufacture difficult, and in most cases nearly as good substitutes of much simpler nature are on the market. The drug industry in this country at present, although not as satisfactory as that of the dyes, is being rapidly developed, and it will not be long before the United States will hold its own in this branch of chemistry.

The last class of organic substances is the fancy organic chemical reagents. These include not only the materials badly needed for scientific research, but also those almost indispensable for analytical work, food testing, etc., as dimethyl glyoxime for the quantitative determination of nickel, cupferron for the separation of iron and copper, phenyl hydrazine for sugar

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separations, and many others. Considerable quantities of these compounds were on hand in this country when the war broke out, held chiefly by university laboratories and distributing concerns. By careful conservation on the part of the universities and greatly advanced prices on the part of the distributing houses, a serious lack of these reagents was not felt until this last year. The manufacturers have not attempted, and will not at present attempt, to produce these compounds, on account of the comparatively small demand, on account of the skilled chemists that it needs for this work, and on account of the very small profits involved. The University of Illinois undertook the work of preparing many of these substances which were needed most. Since the 1st of June a number of graduate students have been employed in this laboratory and have made up to the present time over one hundred different compounds which had not been manufactured in this country before and which were badly needed by laboratories all over the country. In this work special attention has been paid to developing the processes from the laboratory scale of 25 or 50 grams to a scale of 1 or 2 pounds, and thus it has been possible to give the men a training not to be obtained in any other way in a university, a training of the kind most needed now in the chemical industry. At the same time, valuable service has been rendered to scientific, technical, and Government laboratories throughout the country. Moreover, the students have been paid enough so that their living expenses would be covered. Amounts of these reagents varying from a few grams of certain ones to nearly a hundred pounds of others have been made and sent away, and the business already has amounted to between $7,000 and $8,000, which is large if it be considered that not a single piece of apparatus has been used which was not formerly at hand, and not a single man doing the work has had any training outside the university. At the present time the cooperation of other large universities is being sought so that more ground may be covered. It is hoped to form an organization for the manufacture of this class of substances which will continue not only until the war ends, but until such a time as a large American manufacturer will undertake the work, not for profit, but to help the United States become independent of foreign laboratories.

One other phase of chemistry should not be overlooked at the present time, the chemistry of gas warfare. This can hardly be called an industry unless it is determined by the amount of

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money expended for its development. England is spending $125,000 a day simply for its study, and that sum does not include the cost of manufacture of the material actually used in the fighting. In February, 1915, the first attacks were made with chlorine and bromine. Four days after that attack, the English had provided one million troops in France with protective masks. Since that time, the intensive study of poisonous gases and liquids and the protection therefrom has been the serious problem of the leading chemists in the various warring nations. Last spring a large per cent of all the shells fired on the Western front were liquid shells, and that number is increasing continually. The use of gases has been given up to a considerable extent as they are too volatile and soon blown away. What is sought for now especially are liquids, boiling between 100° and 200°, tear-producing and poisonous. These will often remain on the ground for days and prevent the soldiers from remaining there except when wearing their masks. The first attack at Verdun was made with a new liquid which was not absorbed by French gas masks, and it is reported that the original attack on the Italian front a few weeks ago was started with a liquid which had not hitherto been used. The extreme importance of this warfare can immediately be seen, for if it were possible to obtain a poisonous liquid or gas not absorbed by the enemies' masks, and which could be produced and used in large amounts, the chances of breaking through a line not supported by many reserves would be great. There are, at Washington, at the present time, between two and three hundred chemists working continually on the development of different phases of this warfare, from the offensive side as well as the defensive side. An interesting point in connection with this work is the great secrecy needed, since the secret service of the various nations is most active and effective. Not many months ago, it was reported that the Germans used a colorless, odorless liquid or gas which when breathed gradually poisoned the soldiers, caused blindness in the course of a few days, and subsequent death. This report was true, but before the material was used on the Western front the English Secret Service had found out what it was, how much the Germans were capable of manufacturing, had obtained blue prints of the mechanical apparatus, and these were in England long before an attack was made with it. This allowed time for developing sufficient protection for the men.

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It can be seen, therefore, that the present opportunity in chemistry is great, and the advancement already made shows that the American chemists are not behind those of other nations. The demand for men with a chemical training is enormous at the present time, not only for those who have had a training in research, but also those with simply a Bachelor's Degree. One concern wrote to me just the other day, stating that they had sixteen positions to be filled, and other similar instances are arising from time to time. I, personally, feel sure that the demand is not a temporary one but permanent, for the chemical industry in the United States is now on its feet. Whereas the salaries offered beginning chemists five years ago varied from $50 to $75 or $80 a month for a man who had had four years' undergraduate training, and $75 to $100 a month for men with considerable graduate training or even a Doctor's Degree, at the present time a concern would not consider offering less than $1,200 to $1,500 for a man who had had a college training in a good university, or less than $1,500 for a man with some graduate training, while to men with a Ph. D. the offers seldom fall below $2,000 and often are greater than that. This last June, one of our students who received his Doctor's Degree, a man who was not more than an average student, received a position at $2,300, and this fall was raised to $2,700, a salary which puts to shame the majority of the assistant professors' salaries in this and other universities.

It would be possible to consider almost indefinitely the various interesting phases of the chemical field, but I shall simply mention that large numbers of chemists are also needed in the oil industry, for water and food testing, for the development of new and more efficient antiseptics and drugs, for the study of new alloys for all kinds of engines, in fact for innumerable fields of the greatest importance.

Thus a few of the accomplishments of the American chemists and something of what they are attempting to accomplish have been put before you. A relatively large number of these have doubtless begun their chemistry in the high schools, and only when one is reminded of this is the importance of the work of the high school teacher realized. A student never loses his first impression of a subject, and it is possible thus to make or break a man for any field in the first few months of training. The new student must have his interest in the subject aroused, he must be made to feel the importance of it, and he must be able to see that chemistry is a connected field and not a mass of isolated facts.

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PASCAL'S MOUNTAIN EXPERIMENT.

By Willard J. Fisher,
Worcester, Mass.

[Note: Strato of Lampsacus, director of the Lyceum at Athens, B. C. 287-269, called "the Physicist" from his interest and energy in promoting science as distinguished from *a priori* philosophy, seems to have studied the phenomena of air pressure then known, and to have explained what he found by the doctrine, "nature abhors a vacuum." Whether he owed this idea to Aristotle I do not know; but certainly little further progress was made for thirteen hundred years, when, it is said, the Arabian Alhazen seems to have had rather clear ideas about air pressure. In A. D. 1540 Cardan is said to have made attempts to determine the weight of air.

The Florentine pump-makers' observation, that water would not follow the piston above about thirty-two feet, when reported to Galileo led him to observe that nature apparently does not abhor a vacuum above thirty-two feet; and on reflection further, to suggest that the heights to which other liquids could be similarly raised might be inversely proportional to their specific gravities. Though he had previously determined experimentally that air has weight, by compression into a metal globe and weighing, he seems never distinctly to have connected the two sets of phenomena.

His pupil Torricelli was struck by the hint about specific gravities, and suggested mercury as a liquid. He never tried it, however, but passed on the suggestion to his pupil Viviani, who in 1643 did what we now call the *Torricellian experiment*, with the simple *barometer*—a name due to Robert Boyle. Torricelli was clear in his ideas as to the balancing of atmospheric and mercury pressures; "on the surface of the liquid in the basin there weighs a quantity of air fifty miles high." In connection with this experiment he said that it was not only for making a vacuum, "but also to have an instrument which can indicate the changes in the air, now heavier and more dense, now lighter and more subtle."

Descartes seems to have tried the same experiment with mercury twelve years before Torricelli, and in a letter to Father Mersenne to have explained it by air pressure; he complains that Pascal gave him no credit, though knowing about it. However that may be, in 1646 Pascal learned from Petit of Torricelli and Viviani's experiment, and was much struck with the possibility of making an empty space, a vacuum. At Rouen, with his informant Petit, he soon repeated and varied it with mercury and other liquids, using in one case red wine in a tube forty-six feet long. On December 13, 1647, Descartes again wrote Father Mersenne: "I have informed M. Pascal of an experiment to see whether quicksilver rises as high on a mountain top as at the bottom; I do not know whether he has done it." This is perhaps the origin of the famous experiment on the Puy de Dome, called Pascal's but carried out by Florin Perier, husband of Pascal's sister Gilberte. Pascal's proposition to Perier antedates this letter of Descartes to Mersenne by about a month.

Otto von Guericke, who in the midst of the savagery of the Thirty Years' War had carried out, in ignorance of the other researches of his time, experimental work which makes him one of the fundamental authorities, first heard of the Torricellian experiment with mercury and, no doubt, of Pascal's mountain experiment, in 1654, at Ratisbon, where he himself gained a European reputation by means of his air pump and Magdeburg hemispheres. He attempted to repeat the mountain experiment on the Brocken in 1658, but was disappointed by the clumsiness of the servant who carried the barometer and broke it part way there. The journey from Magdeburg was hard and uncomfortable, if not dangerous; already fifty-six years old, he did not try again.

The account which follows is translated from Hachette's edition of Pascal's works, Paris, 1872; it appeared originally in Paris, 1648. Descartes' relation to the discovery is taken from *La Grande Encyclopedie.*

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The old French *toise* (fathom) consisted of 6 *pieds* (feet) of 12 *pouces* (inches) of 12 *lignes* (lines). "According to Nystrom's *Mechanics* 1 *pied du roi* = 12.79 inches," English measure.—WILLARD J. FISHER.

ACCOUNT OF THE GREAT EXPERIMENT ON THE EQUILIBRIUM OF FLUIDS PROPOSED BY M. B. PASCAL FOR THE COMPLETION OF THE TREATISE WHICH HE PROMISED IN HIS *Abstract on Vacuum*[1], AND MADE BY M. F. PERIER, ON ONE OF THE HIGHEST MOUNTAINS OF AUVERGNE, COMMONLY CALLED THE PUY DE DOME.

When I gave to the light of day my abstract under the title, *Experiences Nouvelles Touchant Le Vide, etc.*, in which I employed the maxim of the horror of a vacuum, since it had been universally received, and since I had no convincing proofs to the contrary, there were still certain difficulties which made me suspect the truth of this maxim, for whose clearing up I then contrived the experiment a description of which I am about to give, an experiment which enables me to give a perfect account of that which I am bound to believe about it. I have called it *the great experiment on the equilibrium of fluids*, since it is the most conclusive of all those which can be done on the subject, in that it shows the equilibrium of air and quicksilver, which are, the one the lightest, the other the heaviest, of all the fluids known in nature. But since it was not possible to do it in the city of Paris, and since there are very few places in France suitable for it, and since the city of Clermont in Auvergne is one of the most convenient, I begged M. Perier, counsellor in the Court of Aides of Auvergne, my brother-in-law, to take the trouble to try it. One may see what were my difficulties, and what the experiment is, by this letter which I then wrote him.

Copy of the Letter of M. B. Pascal, Jr., to M. Perier, of November 15, 1647.

Monsieur:

I would not interrupt the continuous labors in which your duties engage you, to discuss with you my meditations on physics, did I not know that they would serve to entertain you in your hours of leisure, and that in place of other things which might be disagreeable you might have a little diversion. Moreover, I feel less hesitation, as I know the pleasure that you get from that sort of discussion. This will be nothing more than a continuation of all those we have had concerning vacuum. You know the philosophers' opinions on that subject; they all have held as a maxim, that nature abhors a vacuum; and almost all, to go farther, have asserted that she cannot allow it, and that she would be destroyed rather than suffer it. Here opinions have been divided; some have been contented simply to say that she abhorred it; others have maintained that she could not suffer it. I have labored, in my *Abstract of a Treatise on Vacuum*, to destroy this latter opinion, and I believe that the experi-

[1]This complete treatise was never published.

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ments which I have there reported suffice to make clear that nature can suffer, and in fact does suffer, a space as large as one may desire, empty of all the materials of which we know and which fall under our senses. My purpose now is, to examine the truth of the first, i. e., that nature abhors a vacuum; and to search for experiments to make clear if the effects which are attributed to the horror of a vacuum are really to be attributed to that, or whether they ought to be attributed to the weight and pressure of the air; since, to state frankly to you my idea, I have difficulty in believing that nature, which is neither animated nor conscious, is susceptible of horror, since passions presuppose a mind capable of experiencing them; and I incline rather to impute all these effects to the weight and pressure of the air, considering them only particular cases of a universal proposition about the equilibrium of fluids, which is to form the major part of the treatise I have promised. Not that I had not the same ideas at the time of producing my *Abstract;* nevertheless, lacking convincing experiments, I did not them dare (and I do not now dare) to give up the maxim of the horror of a vacuum; and I have likewise used this as a maxim in my *Abstract*, having there no other intention than to combat the opinion of those who assert that a vacuum is absolutely impossible, and that nature would suffer her own destruction rather than the least vacuous space. In fact, I hold that we are not permitted to depart even slightly from the maxims which we have received from antiquity, if we are not obliged to by indubitable and invincible proofs. But in that case I hold that it would be the extreme of weakness to make any scruples, and that finally we ought to have more veneration for evident truths than tenacity in received opinions. I cannot give you better evidence of the caution which I use rather than depart from the old maxims than by reminding you of the experiment which I performed in your presence in past days with two tubes, one inside of the other, which show plainly a vacuum within a vacuum. You saw that the quicksilver in the inner tube stayed suspended at the height which it takes in the ordinary experiment, when it was counterbalanced and pressed upon by the weight of the entire mass of air; but, on the contrary, it fell completely, without retaining either elevation or suspension, when, by reason of the vacuum which surrounded it, it was no longer pressed upon or counterbalanced by any air, this having been removed on all sides. You saw then that this height or suspension of the quicksilver increased or diminished as the pressure of the air increased or diminished, and finally that all the heights or suspensions of the quicksilver were always proportional to the pressure of the air.

Surely, after this experiment there would be room for persuasion that it is not a horror of a vacuum, as we deem it, which causes the suspension of the mercury in the ordinary experiment, but rather the weight and pressure of the air, which counterbalances the weight of the quicksilver. But since all the facts of this last experiment of the two tubes, so naturally explained by the pressure and weight of the air alone, can also be explained very plausibly by the horror of a vacuum, I clung to the old maxim; resolved, nevertheless, to search for a complete clearing up of the difficulty by a decisive experiment.

I have now imagined such a one, which shall be by itself sufficient to give us the light for which we search, if it can be carried out with precision. This is, to make the ordinary vacuum experiment several times the same day, in the same tube, with the same quicksilver, now at the base and again at the summit of a mountain, in height at least a hundred to six hundred toises, to test if the heights of the mercury suspended in the tube be equal or different in the two places. You see, no doubt, that the experiment is decisive of the question, and that, should it turn out that the mercury height is less at the top than at the base of the mountain (as I have many reasons for believing, though all who have thought on the subject are of contrary mind), it will necessarily follow that the weight and pressure of the air is the only cause of this suspension of the quicksilver, and not the horror of a vacuum; since it is certain that there is much more air which weighs upon the foot

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of the mountain than on the summit, while one would not say that nature abhors a vacuum at the base of a mountain more than at the summit.

But as trouble usually comes joined to great deeds, I see enough of it in the execution of this plan, since for it must be chosen a very high mountain, near a city containing a person capable of bringing to the test all the needful precision; for, should the mountain be distant, it would be hard to carry there the vessels, the quicksilver, the tubes, and all other needful things, and to undertake the laborious journeys whenever it would be necessary, in order to have placid and convenient weather at the mountain top, which does not often happen there; and as it is also unusual to find outside of Paris people with the qualifications or places with the conditions, I have highly rated my happiness in having on this occasion found both one and the other, since our city of Clermont is at the base of the high mountain of the Puy de Dome, and since I hope of your goodness that you will grant me the kindness of being willing yourself to carry out this experiment; and with this assurance I have made hopeful of it all our Paris scientists, and among others Reverend Father Mersenne, who has already promised to cause his numerous and well-merited friends to share in the hope by letters about it to Italy, Poland, Sweden, Holland, etc. I will not touch upon the means of carrying it out, since I know well that you will omit no circumstance necessary to do it exactly.

I beg of you only that it may be as soon as you may find it possible, and that you will excuse this liberty, to which I am urged by my impatient anticipation of success, without which I cannot put final hand to my treatise promised the public, or satisfy the hope of so many expectant people, who also will be infinitely your debtors. Not that I would wish to diminish my gratitude by the number who will share it with me; as I desire, on the contrary, to share that which they will feel toward you; and on its account to remain, sir, your very humble and very obedient servant,

PASCAL.

M. Perier received this letter at Moulins, where he was on business which made him not his own master; so that, whatever desire he had to carry out the experiment promptly, he was nevertheless unable to do it sooner than last September.

You will see the reasons for the delay, the account of the experiment, and the exactness which he brought to it, from the following letter about it which he did me the honor to write.

Copy of the Letter of M. Perier to M. Pascal, Jr., of September 22, 1648.

Monsieur:

Finally I have done the experiment which you have so long desired. I would earlier have given you this satisfaction; but I have been hindered from it, as much on account of my duties in Bourbonnais, as by the reason that, since my return, the snows or the fogs have so covered the mountain of the Puy de Dome, where I was to carry it out, that, even at the season which is here the finest of the year, I have had trouble to find a day when it was possible to see the top of this mountain, which is usually within the clouds and sometimes above them, even though at the same time it be fair weather in the country: so that I have not been able to fit my convenience to the weather before the 19th of this month. But the pleasure with which I carried it out that day has completely consoled me for the small unpleasantness caused me by so many delays which I could not avoid.

Of this I give you here an ample and truthful account, in which you will see the precision and pains which I brought to it; beside which I

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have thought proper to invite the presence of certain persons not less irreproachable than learned, in order that the sincerity of their testimony might leave no doubt of the certainty of the experiment.

Copy of the Account of the Experiment Made by M. Perier.

The weather of last Saturday, the 19th of this month, was very unsettled; however, as it seemed very fine towards five in the morning, and the top of the Puy de Dome showed itself uncovered, I resolved to go there to do the experiment. So I gave notice of it to certain persons of quality in this city of Clermont, who had asked me to inform them of the day I would go, some of whom are clerics and the rest lay: among the clerics were the Very Reverend Father Bannier, one of the Minimites[2] of this city, who has several times been Corrector (i. e., superior), and M. Mosnier, canon of the Cathedral Church of this city; and among the lay people, Mm. La Ville and Begon, counsellors in the Court of Aides, and M. La Porte, doctor of medicine practicing here; all persons not only very competent in their professions, but also highly cultivated, in whose company I was delighted to carry out this fine project. So we were all together that day towards eight in the morning, in the garden of the Minimite Fathers, which is nearly the lowest place in the city and where the experiment was begun in this way.

First, I poured into a vessel sixteen pounds of quicksilver, which I had rectified during the three days preceding; and having taken two glass tubes of equal size, and each about four feet long, hermetically closed at one end and open at the other, with each one of them I performed the common vacuum experiment in the same vessel; and having brought the two tubes in contact one with the other without withdrawing them from the vessel, it was found that when the quicksilver had come to rest in each it was at the same level, and that in each it was twenty-six pouces, three and one-half lignes above the surface in the vessel. I repeated this experiment in the same place, with the same two tubes, with the same quicksilver, and in the same vessel, two more times, and always it was found that the quicksilver in the two tubes was at the same level and the same height as the first time.

This done, I left behind one of the two tubes in its vessel in continuous experiment; I marked on the glass the height of the quicksilver, and leaving this tube in its place, I begged the Reverend Father Chastin, one of the religious of the house, a man equally pious and competent, who reasons very well in such matters, to take the pains to observe, from time to time during the whole day, if any change took place. And with the other tube and part of the same quicksilver, and with all these gentlemen, I was at the top of the Puy de Dome, elevated above the Minimites about five hundred toises, where, having made the same experiments in the same way as I had made them at the Minimites, it was found that it rested in this tube only at the height of twenty-three pouces, two lignes of quicksilver; instead of at the height of twenty-six pouces, three lignes and a half, as had been found at the Minimites in the same tube; and so, between the heights of quicksilver of the two experiments there was a difference of three pouces, one ligne and a half; which delighted us all with admiration and wonder, and amazed us so that, for our own satisfaction, we wished to repeat it. So I did it again five other times, very exactly, in various parts of the summit of the mountain, now under cover in the little chapel there, now in the open, now in shelter, now in the wind, now in fine weather, now during rain and fogs which occasionally happened, having each time most carefully cleared the tube of air; and there was always found in all these experiments the same height of quicksilver of twenty-three pouces, two lignes, which makes three pouces, one ligne and a half difference from the twenty-six pouces, three lignes and a half found at the Minimites; which satisfied us fully.

After, while descending the mountain, on the way I repeated the same experiment, always with the same tube, the same quicksilver, and the

[2]The Minim Friars of St. Francis de Paul.

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same vessel, at the place called Lafon de l'Arbre, much above the Minimites, but much more below the summit of the mountain; and there I found that the height of the quicksilver at rest in the tube was twenty-five pouces. I repeated it the same time in the same place, and M. Mosnier, one of those named above, had the curiosity to do it himself; he also did it therefore in the same place, and he found always the same height of twenty-five pouces, which is less than that found at the Minimites by one pouce, three lignes and a half, and more than which we had just found at the top of the Puy de Dome by one pouce and ten lignes; which increased our satisfaction not a little, seeing the height of the quicksilver diminish according to the height of the place.

Finally, having returned to the Minimites, I found there the vessel which I had left in continuous experiment, at the same height as I had left it, twenty-six pouces, three lignes and a half; in which height Reverend Father Chastin, who had remained there for observation, informed us no change had occurred during the whole day, although the weather had been very unsettled, now serene, now rainy, now full of clouds, now windy.

I repeated the experiment with the tube which I had taken to the Puy de Dome, and in the vessel where was the tube in continuous experiment; I found that the quicksilver was at the same level in the two tubes, and at the same height of twenty-six pouces, three lignes and a half, as it had been found in the morning in the same tube, and as it had remained during the whole day in the tube in continuous experiment.

I repeated it again for the last time, not only in the same tube which I had used on the Puy de Dome, but also with the same quicksilver and in the same vessel which I had carried there, and I always found the quicksilver at the same height of twenty-six pouces, three lignes and a half, which had been found in the morning; which finished confirming us in the certainty of the experiment.

The next day the Reverend Father de la Mare, priest of the Oratory and theological lecturer of the Cathedral Church, who had been present at what had occurred the morning of the preceding day in the Minimite garden, and to whom I had recounted what had happened on the Puy de Dome, proposed to me to try the same experiment at the foot and at the top of the higher tower of Notre Dame de Clermont, to test if there might occur any difference. To satisfy the curiosity of a man of so great merit, who has given all France proofs of his capacity, I did the same day the common experiment of vacuum, in a certain house which is at the highest place in the city, elevated above the garden of the Minimites six or seven toises, and at the level of the foot of the tower; there we found the quicksilver at a height of about twenty-six pouces, three lignes, less than that found at the Minimites by about half a ligne.

Then I did it at the top of the same tower, elevated above its foot about twenty-six or twenty-seven toises; there I found the quicksilver at a height of about twenty-six pouces, one ligne, which is less than that found at the foot of the tower by about two lignes, and than that found at the Minimites by about two lignes and a half.

(Here follows a numerical resume, which I omit.—W. J. F.)

Behold, in truth, all that happened in this experiment, the account of which all the gentlemen who assisted with it will sign when you desire.

Further, I have to tell you that the quicksilver heights were taken very exactly; but of the places where the experiments were made, those were probably less so.

Should I have enough leisure and convenience, I will have them measured with more precision; and I will also have marked down in hundreds of toises the places on the mountain at each of which I shall have done the experiment, and the heights found for the quicksilver at each of these stations, in order to give you exactly the difference produced by the first hundred toises, that by the second hundred toises, and so with the others; which might serve for arranging a table of it, by the extension of which those who might wish to give themselves the trouble could

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perhaps arrive at a perfect knowledge of the exact size of the diameter of the whole sphere of the air.

I do not despair of sending you some day these differences for hundreds of toises, as much for our satisfaction as for the use the public could get out of it.

If you find any obscurity in this account, I will be able in a few days to enlighten you by word of mouth, being at the point of making a little trip to Paris, where I will assure you that I am, sir, your very humble and very affectionate servant, PERIER.

This account having cleared up all my difficulties, I will not conceal that I received from it much satisfaction; and having seen by it that the difference of twenty toises in elevation makes a difference of two lignes in the height of the quicksilver, and that six to seven toises make a difference of about half a ligne, which was easy to test in this city, I did the ordinary experiment of the vacuum at the top and at the bottom of the tower of Saint Jacques de la Boucherie, twenty-four to twenty-five toises high; I found more than two lignes difference in the height of the quicksilver; and then I did it in a certain house, ninety steps high, where I found very sensibly a difference of half a ligne; which agrees perfectly with the contents of M. Perier's account.

All those who are curious can try it themselves, whenever they please.

CONSEQUENCES.

From this experiment there may be drawn numerous consequences, as—

The means of determining whether two places are at the same level, i. e., equally distant from the center of the earth, or which of the two is the more elevated, if the two are at a distance apart, even though they be antipodes; which would be otherwise impossible.

The small certainty found in the thermometer[3] for marking the degrees of heat, contrary to common opinion; for its water often rises when the heat increases, and on the contrary often falls when the heat diminishes, even though the thermometer has stayed in the same place.

The inequality of the pressure of the air, which, with the same degree of heat, is always found much more pressed in lower places.

All these consequences will be deduced in full in the *Treatise on Vacuum*, and many others as useful as curious.

[3] An air thermometer on the model of Galileo's?

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TO THE READER.

My dear reader, the universal consent of peoples and of the throng of philosophers agrees in the establishment of this principle, that nature would rather suffer her own destruction than the least vacuous space. Certain intellects more elevated have adopted one more moderate; while they have still believed that nature has a horror of a vacuum, they have nevertheless judged that this repugnance has limits, and that it can be overcome by a certain amount of violence; but there has never been anyone to advance this third—that nature has no repugnance whatever for a vacuum, that she makes no effort whatever to avoid it, and that she allows it without trouble and without resistance.

The experiments which I have given you in my *Abstract* have, in my judgment, destroyed the first of these principles; and I do not see how the second can resist this which I am now giving you; so that I no longer make any trouble of accepting the third, that nature has no repugnance whatever for a vacuum, that she makes no effort whatever to avoid it, that all the effects which have been attributed to this horror proceed from the weight and pressure of the air, which is their sole true cause, and that, for lack of knowledge, this imaginary horror of a vacuum has been expressly invented to account for them. Not in this case alone, when the weakness of men has been unable to find true causes, their subtlety has substituted for them imaginary ones, expressed by specious names, filling the ears and not the mind; as when they say that the sympathy and antipathy of natural bodies are the efficient and unique causes of various effects—as if inanimate bodies were capable of sympathy and antipathy; similarly with *antiperistasis*, and numerous other chimerical causes, which bring only an empty satisfaction to men's desire for knowing hidden truths, and which, instead of discovering such, serve only to cover the ignorance of their inventors and to nourish that of their followers.

It is not wholly without regret that I depart from opinions so generally received; I do it only as yielding to the power of truth which constrains me. I have opposed these new ideas as long as I have had any excuse for following the old; the maxims which I have followed in my *Abstract* testify of this sufficiently. But at last the evidence of experiments has forced me to leave opinions in which respect for antiquity had kept me. Moreover, I have left them only little by little and have

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departed from them by degrees; for, from the first of these principles, that nature has an invincible horror of a vacuum, I passed to the second, that she has a horror for it, but one not invincible; and from that I have finally arrived at belief in the third, that nature has no horror whatever for a vacuum.

This is where this last experiment on the equilibrium of fluids has brought me; which I would not have thought to give you complete, without showing you what motives incited me to the search; for that reason I give you my letter of November 16 last, addressed to M. Perier, who took the trouble to do it with all the exactness and precision that can be desired, and to whom all the scientists who have so long desired it will be under great obligation.

And since, for a special advantage, this universal desire has made it famous before its appearance, I am sure that it will not become less renowned after its completion, and that it will give as much satisfaction as the expectation of it has caused impatience.

It was not proper to let the people who had desired it languish for it any longer; and for that reason I could not refrain from giving it in advance, contrary to my plan not to except in the complete treatise (which I have promised you in my *Abstract*) in which I will deduce the consequences that I have drawn from it; which I have deferred doing until this last experiment, as it is needed to make my demonstrations complete. But since that cannot appear so soon, I have been unwilling to keep this any longer, as much to deserve from you more gratitude for my promptness as to avoid the reproach of wrongdoing, which I might expect you to bring against me for delaying too long.

Price of Preprints of the "Status of Mathematics in Secondary Schools."

Preprints of this article, published in the January, February, March and April issues, may be had for 10 cents from Mr. M. J. Newell, High School, Evanston, Ill., or from Mr. Alfred Davis, Francis W. Parker School, 330 Webster Ave., Chicago, Ill.

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SCIENCE TEACHING IN SOUTH DAKOTA.

By Hilton Ira Jones, Ph. D.,
Dakota Wesleyan University, Mitchell, South Dakota.

Educational surveys are not for the purpose of "getting some one" as certain people seemed to fear when the proposition of appropriating state funds was up before the legislature. But as Superintendent McClinton pointed out in his Presidential address, the fact that any authority classes us as twenty-sixth in schools should deeply concern every educator in the state. And surely before we can intelligently set about to remedy our defects, we must have a clear understanding of just what these defects are. Hence the legislature is to be congratulated on having made provision for a thoroughgoing survey of the educational conditions in South Dakota.

In my Presidential address at Watertown before the South Dakota Academy of Science, I called attention to the unfortunate conditions of science teaching in South Dakota, the deplorable consequences resulting, and urged the Academy to make a study of the conditions under which secondary science work is attempted in our state. In accordance with this recommendation I have undertaken to gather such information as I could from the science teachers and others in the many towns of the state which I have visited in the last few years. In addition to the data which I have thus collected from many sources, I sent out a questionnaire to all the high schools in South Dakota. The questions asked were:

1. What science courses are taught in your school?
2. How many teachers give science courses?
3. What is your average science teacher's salary?
4. How many classes per day do your science teachers average?
5. What is the length of your class periods?
6. Do your science classes have single or double laboratory periods?
7. How many students are there in your high school?
8. How many students are taking physical geography? General science? Botany? Zoology? Biology? Chemistry? Physics? Agriculture?
9. What is the (estimated) value of the laboratory equipment used for each science you teach?
10. What is the average annual expenditure for science equipment and supplies?
11. Who determines how much shall be expended?
12. Who determines what shall be purchased?
13. Have your science teachers had special training for this work?
14. How many laboratory sciences have you?
15. Are your science courses gaining or decreasing in popularity?
16. What apparatus and supply company or companies do you find most satisfactory?

That South Dakota educators are ready for an educationa survey and are willing to cooperate and make it successful is

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clearly shown by the unusually large percentage of carefully worked-out answers which I received. Practically all the four-year accredited high schools in the state replied. Nearly all the failures to respond were in the case of small unaccredited high schools, many of which felt, as one principal expressed it, that inasmuch as they had no laboratory or scientific equipment, their data would not be very enlightening or valuable. Consequently, the showing made by the replies to the questionnaire is a little better than the facts.

From the one hundred and twenty-four replies received, I find that the number of schools teaching the several sciences arrange themselves as follows:

Geology	1	Physical Geography	78
Physics	71	General Science	47
Physiology	5	Zoology	10
Chemistry	21	Botany	38
Agriculture	37	Biology	6

It thus appears that the weight of precedent is opposed to the teaching of geology, physiology, biology, and zoology in the high schools of the state, the prejudice against them being in the order named. I find zoology is taught in but two of the larger high schools, biology and physiology in but one, and geology in no large high school. It would seem that the high schools teaching these sciences would do well to inquire whether the special reasons which impel them to teach these sciences are sufficient to justify their continuance in the face of overwhelming public opinion. While there are twenty-one high schools teaching chemistry, judging by the amount of money invested in equipment, there are many more teaching it than should attempt to do so.

The numbers enrolled in the various sciences is of some interest:

	Total Enrollment.		Size of Average Class.
Geology	4		4
Physiology	52		10.4
Zoology	215		21.5
Physics	903		11.3
Chemistry	394		18.8
Agriculture	630		17.02
Botany	674		17.7
Physical geography	1,314		17.0
General science	948		20.1
Biology	105		17.5
	5,239	Average	15.53

The figures showing the salary of the high school science teacher have very little meaning, because in a very large number of cases the science teacher is either principal or superin-

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tendent, and the salary he receives is partly for his science teaching and partly for his work in administration. The average salary appears to be $968.76. The high schools have on the average 1.65 science teachers. The average number of classes is 4.5, but inasmuch as only some dozen high schools possess real science teachers, that is, teachers who are specialists in science teaching, and teach little or nothing else, the figures have no great significance. The class periods are all the way from thirty to sixty minutes in length, with the forty-five-minute period very much predominating. I find that fifty-three high schools report double laboratory periods in all their sciences; twenty high schools have double laboratory periods for some of their sciences, and single for others. Twenty-one high schools have only single periods. These are among the smaller high schools which also have on the average the shorter periods. I have throughout used the word "smaller" high school to indicate an enrollment of less than seventy, as our South Dakota high schools average 71.2 enrollment.[1]

The average valuation placed upon the entire science equipment by the high schools reporting is $637.22, and if every high school had an equipment of this value before it attempted to teach science subjects, the case would not be bad. But when we observe the number of high schools teaching from one to five sciences with an equipment valued at less than $100.00, we see how desperate the need of equipment is. I note for example a high school teaching five sciences with a total equipment valuation of $50.00 and an annual expenditure of $5.00. Such a state of affairs seems incredible to me. I have taught science for ten years and have never spent less than $500.00 a year, and half of this time was spent in high schools. Our annual expenditure at Dakota Wesleyan for the five laboratory courses under my direction is from $1,500.00 to $1,900.00. And how any human being can be expected to teach science in a respectable way with an equipment such as a very large number of South Dakota high schools possess, I confess is beyond me to understand. It simply cannot be done, it is not done, that's all. The average annual appropriation in South Dakota high schools for all the sciences is but $79.42, and remember the average high school has 3.1 science subjects. That gives $26.47 as the average annual cost for supplies and equipment to teach science a year to the average science class of 15.53 pupils or .95 of a cent per pupil recitation. In view of these figures I would

[1]The reader should remember that South Dakota has a population of less than seven to the square mile and not two cities of ten thousand people.

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reply to the question which I am frequently asked, "What is the matter with the science work in South Dakota?" the trouble is that on the average the school boards are trying to get something for nothing, which can no more be done in science teaching than anywhere else. In the Central High School, Muskogee, Okla., we estimated the science courses to average three cents per pupil recitation. The Mitchell High School figures as reported give 2.2 cents per pupil recitation. In general the cost per pupil recitation increases as the size of the school decreases; this, of course, is because the same demonstration apparatus required for a small class will do equally well for a larger one. And yet it is the smaller high schools of South Dakota with the average total enrollment of less than seventy which are responsible for the abnormal figures already given.

The person best qualified to judge as to the needs of a science department is, of course, the instructor, and yet in but seven high schools in the state (and probably here the instructor is an administrative official), does the instructor determine how much should be spent for supplies and equipment. In eight schools the superintendent very generously calls in the instructor for consultation. In three schools the board and instructor determine the amount that should be expended. In seventeen schools the reports show that the superintendent alone determines the expenditure. In twenty-three cases the board and superintendent determine the appropriation, and in thirty-two school systems the board alone determines it. The order of knowledge of the needs is instructor, superintendent, board; but the order of selection is just the reverse. The men who most generally choose are the men who know the least about it. In six towns the board even presumes to say what shall be bought as well as how much shall be expended.

It seems to me the unescapable conclusion which we must come to in answer to the question, "Who is to blame for the poor science work in the high schools of South Dakota?" is the school board. A rather extensive acquaintance with the calibre of the school boards of the average small town strengthens me in this conclusion.

The answers received to the question, "Have your science teachers had special training for this work?" and my acquaintance with the science teachers of the state convince me that there is little common understanding as to what is meant by special training. Special training to me means graduate study in the

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subject, but I note, for example, that one instructor who never had a science course in his high school work and never a course in his college work that he would ever teach in a high school, and who got the only physics training he ever received in a six weeks' summer normal after graduation, reports that he has had special training in science teaching. How large a percentage of the high school science teachers in our state have had special graduate training in the sciences they teach, I am unable to say, but I feel certain the percentage is very small.

The high schools average 3.1 science subjects taught, but only 2.66 sciences which they class as laboratory sciences. There is a vast difference between studying science, the aim of which study is to produce scientists, and studying about science for its "cultural value," after the manner of the bean-eaters of the effete East.

Fifteen high schools report that their science courses are in a static condition, while sixty-six report that they are gaining in popularity, and none report that they are waning in popularity.

Yes, you will say, these are the conditions, but what remedy do you suggest? There are two remedies: First, let the state pay a bonus to the high schools of the state whose work is up to standard as is done in Minnesota. Second, let the state refuse to recognize or accept the credits of any high school which is not up to standard.

SOMETHING NEW.

The old adage that there is nothing new under the sun does not apply in science teaching. New ways of performing experiments, and novel pieces of lecture demonstration apparatus, are continually being announced.

For years the writer has used the Von Nardroff color mixer in illustrating color, primary and complementary colors, etc. This color mixer, while undoubtedly the best of its kind, does not demonstrate color blindness. Physics teachers for years have felt the need of proper apparatus that could illustrate this defect of the human eye.

But now C. M. Westcott of Los Angeles has just developed a very satisfactory device for testing pupils' color perception. It is in the form of lantern slides with forty shades of color ingeniously arranged and numbered. By its use one pupil or an entire class can be singly or collectively tested at the same time, and the exact shade and amount of color defect be ascertained in a few minutes. Every general science teacher and physics teacher should get a set for use in his own classes. It will prove to be one of the most interesting, spectacular, practical, and profitable pieces of apparatus in the laboratory.

See Mr. Westcott's advertisement elsewhere in this issue. C. M. T.

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication, we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

531. *Proposed by G. L. Wagar, Mount Hermon, Mass.*

Given that the sum of the following four factors is -1, find (1) the product of the first pair; (2) the product of the second pair; (3) the product of the sum of the first pair by the sum of the second pair.

$$x+x^4+x^{13}+x^{16}$$
$$x^2+x^8+x^9+x^{15}$$
$$x^3+x^5+x^{12}+x^{14}$$
$$x^6+x^7+x^{10}+x^{11}$$

Taken from *Teachers Handbook of Algebra*, by McLellan.

Solution by L. E. Mensenkamp, Freeport, Ill.

(1) Multiplication of the first pair of factors gives the sum of 16 terms of the type x^k, where $k = 3, 6, 15, 18, 9, 12, 21, 24, 10, 13, 22, 25, 16, 19, 28, 31$. The given condition that the sum of the four factors is equal to -1 may be expressed by the equation

$$x^{16}+x^{15}+x^{14}+\cdots+x+1 = 0, \qquad \text{(a)}$$

or $\dfrac{x^{17}-1}{x-1} = 0$. From the last equation it follows that

$x^{17} = 1$. Then, $x^{18} = x, x^{19} = x^2, \cdots, x^{n+17} = x^n$. (b)

Using these equations, all terms x^k may be reduced to equivalent terms with exponents equal to or less than 16. The product of the first pair of factors then reduces to $x^{16}+x^{15}+x^{14}+\cdots+x$. By equation (a), this equals -1.

(2) Similarly, the product of the second pair may be shown to equal -1.

(3) Finally, the product of the sum of the first pair by the sum of the second pair is the sum of 64 terms of the type x^k. By equations (b), these may be reduced to $4(x^{16}+x^{15}+x^{14}+\cdots+x) = -4$.

A solution similar to the above was received from R. M. Mathews, Riverside, Cal.

Geometry.

532. *Proposed by R. M. Mathews, Riverside, Cal. Lemma for* 513.

A variable circle with center on the line l and passing through a fixed point P, cuts a fixed circle C in A and B. Prove that the common chord AB and the perpendicular to l through P intersect in a fixed point R.

Solution by the proposer.

RP $\perp l$ at D. CE $\perp l$ at E. r = radius of circle C. Draw CR, CD.

Prove RD const.

Proj. of CD on RP = CE.

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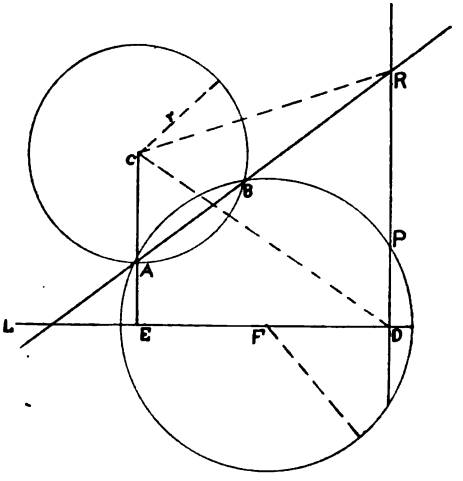
$\overline{RC}^2 = \overline{CD}^2+\overline{RD}^2-2\overline{RD}\cdot\overline{CE}.$

$\overline{RC}^2-\overline{RD}^2 = \overline{CD}^2-2\overline{RD}\cdot\overline{CE}.$

But $\overline{RC}^2-r^2 = \overline{RA}\cdot\overline{RB} = \overline{RD}^2-\overline{PD}^2.$



$\therefore\ \overline{RC}^2-\overline{RD}^2 = r^2-\overline{PD}^2$

$\therefore\ 2\overline{RD}\cdot\overline{CE} = \overline{CD}^2+\overline{PD}^2-r^2$

$$\overline{RD} = \frac{\overline{CD}^2+\overline{PD}^2-r^2}{\overline{2CE}} = \text{a const.}$$

Nelson L. Roray, Metuchen, N. J., remarks that "This proposition enables us to construct a circle tangent to a given circle and passing through two fixed points."—*Editor.*

533. *Proposed by Daniel Kreth, Wellman, Iowa.*

In the triangle ABC perpendiculars to AC and BC, respectively, are drawn from C intersecting AB in E and D. $\angle ACE = \angle BCD = 90°$; $CD = l$, $CE = m$, $AD = n$, and $BE = p$. Find the remaining parts of the triangle.

I. *Solution by L. E. A. Ling, La Grange, Ill.*

Draw the altitude CK on AB.

Put $DK = x$. $EK = y$.

From rt. $\triangle$s ACE, CDB,

$$(n+x)y = (p+y)x. \tag{1}$$

From $\triangle$ CDE,

$$y^2-x^2 = m^2-l^2 \tag{2}$$

From (1) and (2), $y = p\sqrt{\dfrac{m^2-l^2}{p^2-n^2}}$,

and $x = n\sqrt{\dfrac{m^2-l^2}{p^2-n^2}}$.

Now $c = n+p+x+y$

$= n+p+(n+p)\sqrt{\dfrac{m^2-l^2}{p^2-n^2}}$.

If angle BCA is obtuse the formula is

$c = -n-p+(n+p)\sqrt{\dfrac{m^2-l^2}{p^2-n^2}}$

—Ed.

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$$a^2 = m^2+p^2+2py$$
$$= m^2+p^2+2p^2\sqrt{\frac{m^2-l^2}{p^2-n^2}}.$$
$$\therefore a = \sqrt{m^2+p^2+2p^2\sqrt{\frac{m^2-l^2}{p^2-n^2}}}$$

Similarly,

$$b = \sqrt{l^2+n^2+2n^2\sqrt{\frac{m^2-l^2}{p^2-n^2}}}$$

For obtuse angle signs of $2p^2$ and $2n^2$ are negative in formulae for a and b.—Ed.

A solution was also received from Isidore Ginsburg, New York.

534. *Proposed by J. A. van Groos, Portland, Oregon.*

Of the three inscribed squares on the three sides of a triangle, the largest square is on the smallest side.

I. *Solution, L. E. A. Ling, La Grange, Ill.*

Let $a>b>c$ be the sides of the $\triangle$, and h, h', h'', be the altitudes of the $\triangle$ and x, y, z, respectively, the sides of the inscribed squares.

To prove $z^2>y^2>x^2$.

Proof. $a : x = h : h-x.$

Then $$x = \frac{ah}{a+h}.$$

Similarly, $$y = \frac{bh'}{b+h'}.$$

$$\therefore \frac{x}{y} = \frac{b+h'}{a+h'}. \quad (ah = bh' = 2\triangle s.)$$

Also $$h' = \frac{ah}{b}.$$

Whence, $$\frac{x}{y} = \frac{b^2+ah}{ab+bh}$$

Since $a>b$, put $a = b+d$

Then $$\frac{x}{y} = \frac{b^2+bh+hd}{b^2+bh+bd}$$

Now $bd>hd (c>h,\ bd>cd)$

$$\therefore y > x.$$
$$\therefore y^2 > x^2.$$

Similarly, $z^2 > y^2.$

$z^2>y^2>x^2.$

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let c, h_c and x_c denote the side of a triangle, the altitude upon the side and the side of the square inscribed upon the side respectively.

Then it is easily proved that

$$x_c = \frac{ch_c}{h_c+c}$$

$$x_a : x_b = \frac{ch_c}{h_c+c} : \frac{bh_b}{h_b+b}$$

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$$= \frac{h_b + b}{h_c + c}$$

$$= \frac{A\sin C + A\sin B}{\dfrac{\sin(B+C)}{A\sin B + A\sin C}}$$

$$= \frac{\sin C\sin(B+C) + \sin B}{\sin B\sin(B+C) + \sin C}$$

But $\sin C\sin(B+C) + \sin B - \sin B\sin(B+C) - \sin C$ is equal to $(\sin B - \sin C)(1 - \sin(B+C))$, a positive number, if $B > C$.

$\therefore x_c > x_b$ if $B > C$ or $c < b$.

Note: If $B + C = 90$, then $(\sin B - \sin C)(1 - \sin(B+C)) = 0$ and $x_c = x_b$. Hence the theorem is not universally true.

This exception was also noted by the proposér in a solution to the problem. A solution was also received from Charles H. Bartlett, Champaign, Ill. —Editor.

535. *Proposed by Frank Edwin Wood, Albuquerque, N. M.*

Let PA and PB be two chords of a circle, let PC be the perpendicular to AB, then $PA \cdot PB = PC \cdot 2R$, where R is the radius.

I. *Note by L. E. Mensenkamp, Freeport, Illinois.*

This is a form of the well known theorem in geometry which is usually stated as follows: *The rectangle formed by any two sides of a triangle is equivalent to the rectangle formed by the altitude upon the third side and the diameter of the circumscribing circle.* For a proof of the theorem, see Milne's *Plane and Solid Geometry*, p. 194.

Reference to the proof of this theorem in standard texts was also made by L. E. A. Ling, Murray J. Leventhal and Isidore Ginsburg. It is treated as a corollary of the theorem mentioned above in a solution by Emlyn Roberts, a student in Dunmore (Penn.) High School. The solution below differs from the standard proofs.—Ed.

II. *Solution by R. M. Mathews, Riverside, Cal.*

PAB is a triangle inscribed in a circle, so

$$\text{Area } \triangle PAB = \frac{PA \cdot PB \cdot AB}{4R}.$$

Also,

$$\text{Area } \triangle PAB = \tfrac{1}{2}PC \cdot AB$$

$$\therefore \frac{PA \cdot PB \cdot AB}{4R} = \tfrac{1}{2}PC \cdot AB$$

whence $PA \cdot PB = PC \cdot 2R$.

Solutions were also received from Charles H. Bartlett, Frank Brink, Felix S. Hales, David B. Munroe, Ella M. Richards, Nelson L. Roray and the Proposer.—Editor.

News Notes.

The editor is sure that many will be interested in the following extracts from a letter recently received from Norman Anning, dated October 27, 1917, mailed "somewhere in France."

All goes well. Am 'carrying on' with the kind of work I came over to

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do. . . . About a year ago you had a problem expressing $(x^2+y^2+z^2)^2$ as the sum of three squares. Find enclosed a general solution. Have no opportunity of studying mathematics or doing problems other than those in the geometry of location and the arithmetic of equating 25 francs to the H. C. of L.

Sequel to Problem 502.

By Norman Anning.

To express

$(x^2+y^2+z^2)^n$ (x, y, z, n, positive integers)

as the sum of three squares.

Let $y^2+z^2 = s^2$ and let

$(x+is)^n = p+iq, \qquad (i^2+1 = 0).$

Then

$(x-is)^n = p-iq.$

And, multiplying,

$(x^2+s^2)^n = p^2+q^2,$

$$(x^2+y^2+z^2)^n = p^2+q^2\left(\frac{y^2+z^2}{s^2}\right),$$

$$= p^2+\left(\frac{qy}{s}\right)^2+\left(\frac{qz}{s}\right)^2.$$

Note that q is divisible by s and, consequently, $\left(\frac{qy}{s}\right)$ and $\left(\frac{qz}{s}\right)$ are integers. We have thus a way of expressing any positive integral power of the sum of three squares as the sum of three squares.

Example: $n = 3.$

$(x+is)^3 = (x^3-3xs^2)+i(3x^2s-s^3).$

Then

$$\begin{aligned}(x^2+y^2+z^2)^3 &= x^2(x^2-3y^2-3z^2)^2,\\ &\quad +y^2(3x^2-y^2-z^2)^2,\\ &\quad +z^2(3x^2-y^2-z^2)^2.\end{aligned}$$

Putting $x = 1, y = 2, z = 6$ we have

$41 = 1^2+2^2+6^2,$

$41^3 = 74^2+119^2+222^2.$

The same method can be used for any number of squares other than three.

PROBLEMS FOR SOLUTION.

546. *Proposed by W. W. Gorsline, Crane Technical High School and Junior College, Chicago.*

The following six groups of numbers, A, B, C, D, E, F, comprise a well known game or "puzzle." Any number less than 64 is selected and the groups in which it occurs are denoted, e. g., 37: in A, C and F. By adding the first numbers in the respective groups the number is determined, as $1+4+32 = 37$. Find the secret of arrangement of numbers and possibly derive a formula of arrangement for n groups.

A								B							
1	3	5	7	9	11	13	15	2	3	6	7	10	11	14	15
17	19	21	23	25	27	29	31	18	19	22	23	26	27	30	31
33	35	37	39	41	43	45	47	34	35	38	39	42	43	46	47
49	51	53	55	57	59	61	63	50	51	54	55	58	59	62	63

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C								D							
4	5	6	7	12	13	14	15	8	9	10	11	12	13	14	15
20	21	22	23	28	29	30	31	24	25	26	27	28	29	30	31
36	37	38	39	44	45	46	47	40	41	42	43	44	45	46	47
52	53	54	55	60	61	62	63	56	57	58	59	60	61	62	63

E								F							
16	17	18	19	20	21	22	23	32	33	34	35	36	37	38	39
24	25	26	27	28	29	30	31	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63	56	57	58	59	60	61	62	63

547. *Proposed by Norman Anning, France.*

The cap and sill of a high trestle bent are respectively 150 and 400 inches long. Find the lengths of three intermediate caps which are so spaced that the diagonal braces are parallel from top to bottom.

Geometry.

548. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Three points, A, B, and C, start from S on the circumference of a circle to move around the circumference at uniform rates, a, b, and c, respectively. If length of the circumference is P and $c>b>a$ find the condition that the first time they are together again shall be at S; also the time that is required for them to meet again at S.

549. *Proposed by Murray J. Leventhal, New York City.*

Given an equilateral triangle, ABC, and point P, so that PA = PB +PC. Show that the locus of P is a circle. [From a New York City examination for teachers.]

550. *Proposed by Daniel Kreth, Wellman, Ia.*

Given the altitude and radii of the circumscribed and inscribed circles of a plane scalene triangle, to construct it and determine its sides.

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

285. *Proposed by M. W. Arps, U. S. S. Ohio, c-o Postmaster, New York.*

"A" claims that if two balls of equal diameter, but of different material, one being lead and the other wood, be dropped in air from a height of one mile, that they would both reach the ground at the same time.

"B" claims that the lead ball would reach the ground first.

Which is correct?

286. *Proposed by John C. Packard, Brookline, Mass.*

Why does the image in a plane mirror, held parallel to the object, appear reversed but not inverted?

287. *Proposed by O. L. Brauer, Selma, Cal.*

To what extent is crystal formation dependent on water of crystallization?

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288. *Proposed by Clifford Laisy, West Technical H. S., Cleveland, Ohio, through W. A. Tippie.*

Reconcile these two statements of electrical phenomena: (*a*) electric charges are always located on the surface of conductors; (*b*) electrical resistance of a uniform conductor is inversely proportional to the square of the diameter.

Please answer questions numbered 289 and 290 in the following lists: Submitted by Walter N. Lacy, Anglo-Chinese College, Foochow, China.

PHYSICS, 1ST TERM, JUNE, 1917.

Answer only 8 questions; but at least one question from each group must be answered.

GROUP I.

1. How can the specific gravity of a liquid be found? Give reasons for everything done in this method.
2. Make a diagram to show how you would arrange 4 pulleys to lift a heavy weight, and explain how you could find the efficiency of the system.
3. Why do people fan themselves in summer? Explain fully. Tell how you can prove the correctness of your answer.

GROUP II.

4. A man rows a boat across a stream three-fourths of a mile wide, at the rate of 3 miles per hour. The current carries him down stream at the rate of 2 miles per hour. How long does it take him to cross the stream?
5. Depths of the sea are measured by lowering some kind of a pressure gauge into the sea. When this is done until the gauge shows a pressure of 1.3 kg. per sq. cm., what is the depth? (The specific gravity of sea water may be considered as 1.026.)
289. If a burner can heat 2 kg. of water from 10° to 80° C. in 10 minutes, how much water can it boil away into steam in one hour?

GROUP III.

7. Tell what you can about Newton, and what he did for Physics.
8. When you cut cardboard with scissors, why do you open them wide and cut near the point where the two blades are pivoted together?
9. Which is the more useful formula for measuring the efficiency of a motor or engine, $\frac{\text{work out}}{\text{work in}}$ or $\frac{\text{power out}}{\text{power in}}$? Give reasons for your answer.
10. What does a thermometer measure? How? Describe the Centigrade thermometer.
11. Give a brief account of the history of the steam engine.

Submitted by Dr. Lyman C. Newell, Boston University, Boston, Mass.

CHEMISTRY, SEPTEMBER, 1917.

Time: one hour, thirty minutes.

GROUP I. (*Answer two questions in this group.*)

1. State the special property on which the use of each of the following is based: Magnesium, ammonium sulphate, calcium carbide, mercury, thermit.
2. Describe the process of manufacturing each of the following: Sodium hydroxide, lime, nitric acid.
3. (a) Describe the contact process of making sulphuric acid. (b) How is copper purified? (c) What is the difference between gunpowder and smokeless powder?

GROUP II. (*Solve one problem in this group.*)

1. Sixty grams of mercuric oxide are decomposed; what volume of oxygen at 91° C. and 380 mm. is liberated?

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2. How many gm. of gold in a 14 carat ring which weighs 14 grams?

290. If 2 gm. of potassium chloride yield 3.84 gm. of silver chloride, what is the atomic weight of potassium?

(Note.—At. wts.: Hg = 200.5, Ag = 108, Cl = 35.5.)

GROUP III. (*Answer two questions in this group.*)

1. Describe an experiment to illustrate neutralization. Sketch the apparatus. Write the equation in the ionic form.

2. Describe the method by which you prepared one of the following: (a) CO_2; (b) sulphurous acid; (c) nitrogen. Sketch the apparatus.

3. Describe an experiment to illustrate one of the following: (a) Supersaturation; (b) electrolytic dissociation; (c) hydrolysis.

4. Describe a method to find one of the following: (a) The per cent of solid in a given solution; (b) the equivalent weight of aluminium.

5. What is the test for (a) $Cl-$, (b) a sulphate, (c) ammonia?

GROUP IV. (*Answer two questions in this group.*)

1. (a) Explain efflorescence. (b) State and illustrate Avogadro's hypothesis. (c) Interpret these: O, O_2, 2O, O_3.

2. What is the formula of ammonia gas? State fully how this formula is found by experiment.

3. (a) Complete and balance $Pb(NO_3)_2 + - = PbCl_2 + -$. (b) Write the name and formula of the sodium salt of permanganic acid, of the sulphide of bismuth, of the hydroxide of aluminium. (c) What is the name of HCO_3-, of $H+$, of $OH-$?

GROUP V. (*Answer two questions in this group.*)

1. (a) What is the per cent of water in potatoes? (b) How would you test coal ashes for iron?

2. Write 50 words on (a) enzymes or on (b) fuel value of food.

3. What is copperas, blister copper, corrosive sublimate, chalk, ferrochrome, lime, alum, limewater, sterling silver, a diamond carat? What is meant by (a) a water analysis and (b) decomposition of water by electricity?

SOLUTIONS AND ANSWERS.

254. *A Correction.*

The answers by Mr. Hughes should read 36° 26′ 31.7″ and $E = 206 \div 2 + 500 \cos A = 206 \div 804 = .256$.

269. *Proposed by W. A. Hedrick, Central High School, Washington, D. C.*

What do you think of the questions so often asked by the psychologists to which one and only one answer is possible, as in Starch's *Educational Measurements?* They are like this taken from Hall & Bergen, p. 189.

"Supply the omitted word."

Two points so placed with respect to a lens that an object placed at either of them will have an image at the other are called..... .... of the lens.

This question suggests another. How many readers of this department would like to get together on a set of tests in physics, or chemistry, or other science corresponding to Courtis's *Practice Tests in Arithmetic?* (Write to the Editor of this department at University School.)

The following have signified their desire to go ahead with tests along the line proposed either in physics or chemistry:

S. R. Powers, University of Minnesota High School.
T. R. Wilkins, University High School, Chicago.
P. C. Hyde, Newark Academy, Newark, N. J.
Arthur B. Bucknam, Crosby High School, Waterbury, Conn.
Walter N. Lacy, Anglo-Chinese College, Foochow, China.
Franklin T. Jones, University School, Cleveland, Ohio.

Others who desire to get into touch with this movement will please communicate at once with the Editor of this department.

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RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

The Determination of the Electronic Charge *e*.

The importance of the value of the charge of the electron made its exact measurement a much desired accomplishment. It remained for an American physicist, Professor Robert A. Millikan of the University of Chicago to carry out this work. In the introduction to *The Electron*[1] he says: "Science, like a planet, grows in the main by a process of infinitesimal accretion. Each research is usually a modification of a previous one; each new theory is built like a cathedral through the addition of many builders of many different elements." This work of Professor Millikan's grows out of, and is based upon, the results of earlier investigations carried on in the Cavendish laboratory.

The first attempt at a direct determination of *e* was made by Professor J. S. Townsend in 1897, who used a method depending upon the condensation of saturated water vapor on ions. The final value depended upon a measurement of the total electronic charge, the total weight of the cloud, and the average weight of the droplets. This last was found by observing the rate of fall of the cloud under gravity and computing the mean radius by the aid of a purely theoretical formula known as Stokes's Law. He divided the weight of the cloud by the average weight of the droplets to obtain the number of droplets. This he assumed to be the same as the number of ions. Dividing the total charge by the number of ions he found the average charge carried by each ion, that is, *e*.

A second attempt was made by Sir J. J. Thomson by a method resembling that of Townsend in all its essential particulars. Later, H. A. Wilson devised a further modification. All three methods, however, were weak in the following particulars: (1) the assumption that the number of ions is the same as the number of drops; (2) the assumption of Stokes's Law, which might well be expected to be in error when applied to small drops; (3) the assumption that the droplets were all alike and fell at the same rate, uninfluenced by evaporation or other causes of change; (4) the assumption of no convection currents in the gas when the rate of fall of the cloud was being measured. There were, in addition, experimental difficulties peculiar to each method. Consequently the values of *e* resulting from this early work were quite uncertain, having a probable error of several per cent.

In 1906 Professor Millikan repeated Wilson's experiment, securing more consistent results; but, what is more important, he rapidly improved the methods of measuring *e* until in 1909 he was able to make all the measurements on individual droplets. Thus he was able not only to eliminate ultimately all the questionable assumptions and experimental uncertainties involved in the cloud method but also to examine the

[1]This article is based upon, and quotes freely from, a portion of *The Electron*, by Professor R. A. Millikan, a book just published by the University of Chicago Press (see page 762 of the November issue of this journal). It deals with the measurement of *e*, not only describing the author's remarkable work but also giving the historical background and the significance of the value of the electronic charge in connection with various branches of physics. It is written in the easy, readable style characteristic of Professor Millikan and brings this particular line of research before students of physics who do not have ready access to original sources. Although not a "popular" book, it is adapted to the general reader.

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properties of individual isolated electrons and to determine whether different ions actually carry one and the same charge. The final result of the work has been both an exceedingly accurate determination of e and conclusive proof of the atomic nature of electricity, a thing predicted by many but heretofore impossible of experimental test.

In the earlier work he was concerned with a plan for eliminating the error due to the evaporation of the droplets of water and sought to obtain an electric field strong enough to exactly balance the force of gravity upon the cloud. It was found not possible to balance the cloud but it was possible to do something much better, namely to hold individually charged drops suspended for a number of seconds. Later, while working with these "balanced drops," he noticed that now and then one of them would suddenly change its charge and begin to move up or down in the field, evidently because it had captured an ion, in the one case a positive, and in the other a negative. This made it possible to measure the charge carried by a single atmospheric ion. For by taking two speed measurements on the same drop, one before and one after it had caught an ion, he could eliminate entirely the properties of the drop and of the medium and deal with a quantity which was proportional merely to the charge on the captured ion itself.

In the fall of 1909 an apparatus was constructed with which it was possible to use oil drops which, being free from evaporation, could be held under observation for long periods. Two horizontal brass plates, 25 cm. in diameter and 16 mm. apart, formed the chamber in which the drops were studied. Drops of oil were blown with an atomizer into a chamber above the upper plate. These minute droplets, most of them having a radius of the order of one-thousandth of a millimeter, slowly fell in the chamber and occasionally one would find its way through a minute pin hole in the center of the upper plate. These oil drops were illuminated by a powerful beam of light projected into the space between the plates and when viewed through a short focus telescope appeared as bright stars against a black background.

The drops were found in general to have been slightly charged by the frictional process involved in blowing the spray, so that if the field were thrown on in the proper direction they would be pulled upward. Just before the drops reached the upper plate the plates would be short-circuited, when the droplets would fall under gravity until close to the lower plate. Then the direction of the motion would be again reversed by throwing on the field. In this way the drop could be kept moving back and forth between the plates for a long time.

But the interesting thing that happened was this: whereas the velocity of any drop under the influence of gravity was the same in all cases, under the influence of the electric field the velocity changed from time to time. The change was, however, always by the same amount or by a small integral multiple of this amount. Thus when the drop was positive a decrease in speed by one of these amounts indicated the capture by the droplet of a negative ion, while an equal increase in speed meant that a positive ion had been caught. Although the nature of thousands of ions was observed in this way, in no case was there found to be a change which did not correspond to the value of the smallest charge ever captured or else a very small multiple of that charge.[2]

In this connection it should be mentioned that these same experiments furnished the proof that all static charges both on conductors and insulators are built up of electrons, for it was found that the initial velocity

[2]See page 554 of the June number of this journal.

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of a droplet under the influence of the field was in all cases a multiple of the difference of velocity associated with the electronic charge. Experiments were tried on thousands of drops in different media, some of the drops being made of nonconductors like oil, some of semiconductors like glycerin, some of excellent metallic conductors like mercury. In every case, the initial charge placed upon the drop by the frictional process, and all the dozen or more charges which resulted from the captur› by the drop of ions, were found to be exact multiples of the smallest charge caught from the air.

We have seen how the atomic nature of electricity was proved and that it is possible to measure the effect of a single unit of charge. We will now examine into the method of getting at the value of the charge. Millikan showed that the velocity with which a drop moves is proportional to the force acting on it and independent of the electric charge except as it affects the force. Accordingly,

$$\frac{v_1}{v_2} = \frac{mg}{Fe_n - mg}$$

in which v_1 and v_2 are the velocities of the drop under the influence of gravity and of the electric field respectively, F the field intensity, e_n the charge on the drop, m the mass of the drop and g the gravity constant. If the mass of the drop were known, it would be an easy matter to evaluate e, but the mass of a single small drop can be known only through Stokes's Law already referred to, which gives the velocity v_1 of a drop of radius a and density σ falling under the influence of gravity in a medium of viscosity η as follows:

$$v_1 = \frac{2ga^2\sigma}{9\eta}$$

Combining this with the first equation and eliminating m by means of the formula

$$m = 4/3\pi a^3\sigma$$

we have

$$e_n = \frac{4}{3\pi}\left(\frac{9\eta}{2}\right)^{3/2}\left(\frac{1}{g\sigma}\right)^{\frac{1}{2}} \frac{(v_1+v_2)v_1^{\frac{1}{2}}}{F}$$

which contains only constants or easily measured quantities.

On finding that drops of different sizes gave different values of e, Millikan questioned the validity of Stokes's Law and initiated a series of elaborate experiments at the Ryerson laboratory to find the correction which must be applied in the case of very small drops. At the same time the coefficient of viscosity of air, which appears in the formula in the 3/2 power, was determined with great accuracy and a new apparatus of great refinement was constructed. After about two years of work the final value of e was announced in 1916 as follows:

$$e = 4.774 \pm .005 \times 10^{-10} \text{ absolute electrostatic units.}$$

To indicate the importance of this result, we quote from *The Electron:* "As soon as e is known it becomes possible to find with the same precision which has been attained in its determination the exact number of molecules in a given weight of any substance, the absolute weight of any atom or molecule, the average kinetic energy of agitation of an atom or molecule at any temperature, and a considerable number of other important

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molecular and radioactive constants. In addition, it has recently been found that practically all of the important radiation constants like the wave-lengths of X-rays, Planck's h, the Stefan-Boltzmann constant σ, the Wien constant c_2, etc., depend for their most reliable evaluation upon the value of e. In a word, e is increasingly coming to be regarded, not only as the most fundamental of physical or chemical constants, but also the one of most supreme importance for the solution of the numerical problems of modern physics."

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for August; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "Plant Life on the Peaks," Blanche H. Soth; "How Brazil Nuts Grow," H. E. Zimmerman; "Uses of Cacti," Paul G. Russell.

American Journal of Botany, for November; *Brooklyn Botanic Garden; $5.00 per year, 60 cents a copy:* "Effect of Soil Temperature on the Growth of Bean Plants and upon Their Susceptibility to a Root Parasite," Donald Reddick; "The Development of Cortinarius Pholideus," W. H. Sawyer, Jr.; "Leaf-structure as Related to Environment," Herbert C. Hanson.

American Mathematical Monthly, for November; *5548 Kenwood Ave., Chicago; $3.00 per year:* "The Significance of Mathematics," E. R. Hedrick; "The Linear Function and the Line," Joseph Nyberg; "The Graph of $F(x)$ for Complex Numbers," A. F. Frumveller; "An Intrinsic Equation Solution of a Problem of Euler," P. R. Rider.

Geographical Review, for November; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Aeronautical Maps and Aerial Transportation," Henry Woodhouse; "Saving the Crops from Injury by Frost," Alexander McAdie; "The Virgin Islands of the United States," Theodore de Booy; "The Lau Islands of Fiji," W. G. Foye; "The Distribution of British Cities, and the Empire," Mark Jefferson.

Journal of Educational Psychology, for October; *Baltimore, Md.; $2.50 per year, 30 cents a copy:* "The Power of the Eye to Sustain Clear Seeing under Different Conditions of Lighting," C. E. Ferree and Gertrude Rand; "The Effect of External Incentives on Improvement," J. C. Chapman and R. B. Feder; "A Detailed Study of Whipple's Range of Information Test," J. C. Bell; "Aphasic Performance in the Terman Vocabulary Test," F. L. Wells.

Journal of Geography, for December; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Suggestions for Teaching Elementary Geography," R. H. Whitbeck; "The Food Surplus of South America Available in Time of War," George B. Roorbach; "The Use of Geographic Materials," Robert M. Brown; "Wheeling, West Virginia (Map)," Helen M. Garden; "The Condition of Geography in the High School and Its Opportunity," Carl O. Sauer; "Newfoundland," E. M. Jones.

Photo-Era, for October; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "System in the Studio," Pirie MacDonald; "Tone-Rendering and Quality in Gaslight-Papers," T. D. Tennant; "A Use for Old Bromide Paper," S. Watmough Webster; "Picturing Children Afield," Charles J. Adams; "Focusing in Portraiture"; "Six Years, Twelve Tears and a Pinhole-Camera," Edwin B. Whiting; "Holding a Vest-Pocket Camera," Charles R. Denton; "Restoring Daguerreotypes," C. E. Bold.

Physical Review, for November; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "Oscillating Systems Damped by Resistance Proportional to the Square of the Velocity," J. Parker Van Zandt; "An Experimental Investigation of the Total Emission of X-Rays from Certain Metals," C. S. Brainin; "The Pressure Increase in the Corona," Earle H. Warner; "The Ionizing Potentials of Gases," A. L. Hughes and A. A. Dixon; "A Determination of the Ratio of the Specific Heats of Hydrogen at 18°C. and —190°C.," Margaret Calderwood Shields; "Theoretical Considerations Concerning Ionization and 'Single-Lined Spectra,'" H. J. Van Der Bijl; "The Parallel Jet High Vacuum Pump," William W.

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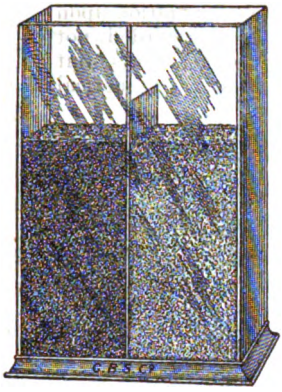

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Crawford; "A Determination of the Efficiency of Production of X-Rays," Paul T. Weeks; "A Study of Apparent Specific Volume in Solution," Leroy D. Weld and John C. Steinberg; "The Absorption of Mercury Vapor by Tin-Cadmium Alloy," L. A. Welo.

Popular Astronomy, for December; *Northfield, Minn.; $3.50 per year:* "Zenith Meteors," William H. Pickering; "Are the Spiral Nebulae Milky Ways?" M. G. Renaudot; "How to Determine the Correct Time Without Apparatus and Without Knowing the Meridian," Ernesto Nelson; "The 100-inch Telescope at Mount Wilson," Jennie B. Lasby.

School Review, for November; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "A Statistical Study of the Scholastic Records of 404 Junior and Non-Junior High-School Students," Paul Clifford Stetson; "Supervised Study and the Science Laboratory," Elliot R. Downing; "The Junior High School," L. McCartney; "The Supervision of Extra-Curricular Activities," Elmer Harrison Wilds.

School World, for November; *Macmillan Company, London, Eng.; 7s. 6d. per year:* "The Secondary-School Examinations Council"; "Books on the Method, Philosophy, and History of Science," R. A. Gregory; "Modern Humanistic Studies," C. H. C. Osborne; "Schools and Public Libraries," John Swain; "Standardising and Competitive Examinations."

FORTY-FIVE MILLION BARRELS OF SALT.

The domestic consumption of salt in 1916 was 45,720,860 barrels of 280 pounds each, an increase of more than 7,000,000 barrels over the consumption of 1915. According to statistics compiled under the direction of R. W. Stone, of the United States Geological Survey, Department of the Interior, the domestic production of salt in 1916 was 45,449,329 barrels, the imports were 871,992 barrels, and the exports 600,461 barrels. This was an increase of 19 per cent in the quantity of salt produed. The total value of the salt was $13,645,947.

Michigan, as usual, was the largest producer, and New York was a close second. The production, in barrels, by the leading states was as follows: Michigan, 14,918,278; New York, 14,087,750; Ohio, 6,706,193; Kansas, 4,564,793; California, 1,124,236.

Perhaps the most marded feature in the salt industry in 1916 was the great increase in quantity of brine sold as such or used by chemical works, the increase being 37 per cent and the total production over 18,000,000 barrels. The production of rock salt increased over 17 per cent and amounted to 9,973,950 barrels, valued at $2,665,270. On the other hand, the production of evaporated salt increased only 5 per cent, to 17,575,629 barrels, but the value was $10,149,412, an increase of nearly 15 per cent.

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Examples in Engineering, by F. E. Austin, Hanover, New Hampshire. 90 pages. 12.5×19.5 cm. Cloth. 1917. $1.25. By the author.

How to Make Low Pressure Transformers, by F. E. Austin, Hanover, New Hampshire. 22 pages. 11.5×18 cm. 1916. $0.40. By the author.

How to Make High Pressure Transformers, by F. E. Austin, Hanover, New Hampshire. 46 pages. 11.5×18 cm. Paper. 1917. $0.65. By the author.

Examples in Magnetism, by F. E. Austin, Hanover, New Hampshire. 90 pages. 12.5×19 cm. Paper. 1916. $1.10. By the author.

Preliminary Mathematics, by F. E. Austin, Hanover, New Hampshire. 169 pages+iv. 12×19.5 cm. Cloth. 1917. $1.20. By the author.

Experimental General Science, by Willard M. Clute, Flower High School, Chicago. Pages vii+303. 12.5×18.5 cm. 96 illustrations. Cloth. 1917. $1.25. P. Blakiston's Son & Co., Philadelphia.

Mammalian Anatomy—with Special Reference to the Cat, by Alvin Davison, Lafayette College. Pages xi+243. 14.5×20 cm. Cloth. 1917. $2.00 net. P. Blakiston's Son & Co., Philadelphia.

Differential and Integral Calculus, by H. B. Phillipps, Massachusetts Institute of Technology. Pages v+162+v+194. 12.5×19 cm. Cloth. 1916. John Wiley & Sons, New York City.

Junior High School Mathematics, by William L. Vosburgh, Boston Normal School. Pages vii+146. 13×19 cm. Cloth. 1917. $0.75. The Macmillan Company, New York City.

Laboratory Manual in General Chemistry, by William J. Hale, University of Michigan. 13.5×19 cm. Cloth. 1917. $1.50. The Macmillan Company, New York City.

A Textbook in the Principles of Science Teaching, by George R. Twiss, State High School Inspector, Columbus, Ohio. Pages xxiv+486. 14.5×20.5 cm. Cloth. 1917. $1.40. The Macmillan Company, New York City.

Stony Island. A Plea for Its Conservation, by Zonia Baber, School of Education, University of Chicago. 16 pages. 15×23 cm. Paper. 1917. The University of Chicago Press.

BOOK REVIEWS.

Third-Year Mathematics for Secondary Schools, by Ernst R. Breslich, Head of the Department of Mathematics in the University High School, The University of Chicago. Pages xviii+369. 14×20 cm. With tables, $1.50, postage extra; without tables, $1.00. 1917.

Logarithmic and Trigonometric Tables. Pages 118. 14×20 cm. 75 cents, postage extra. The University of Chicago Press.

The third book of the series of textbooks on correlated secondary mathematics reveals the carefully planned continuation of the methods of the other two volumes. It begins with simple algebraic functions which are represented by graphs and used in the solution of problems in variation. This leads naturally to trigonometric functions in the second chapter. Then comes the solution of algebraic and trigonometric equations and other topics in algebra. The chapter on logarithms prepares for the solution of triangles, leading to the relations between the functions of several angles. Next comes the binomial theorem, progressions, and equations in two unknowns. The last ninety pages are devoted to areas of surfaces, volume, and theorems of solid geometry. A summary of the assumptions and theorems of geometry contained in the first two volumes is given in the final chapter.

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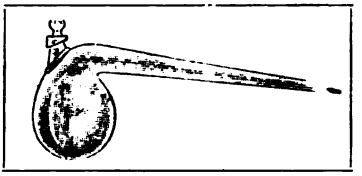

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Automatic Exercises in Arithmetic, by Mrs. M. W. Arleigh, Supervisor of Arithmetic, San Francisco State Normal. The Crown Publishing Company, 1130 Mission St., South Pasadena, Cal.

These exercises in arithmetic are published in 16-page leaflets, 12.5×17.5 cm., with space to work the exercises. The leaflets provide a great amount and variety of material so arranged that the pupil can work with the smallest possible aid from the teacher. The ten books now published contain 2420 exercises in fractions. Concrete material is sewed into three of the books ready for use. The price is: 50 sets, $10; 100 sets, $17; sample sets post paid, 25 cents.

The directions in the books are carefully written and have been thoroughly tried out. Children can read them and work without asking questions. One thing is introduced at a time. As the books have been adopted already in several school systems, it seems as if they are worthy of the attention of superintendents of schools generally. H. E. C.

How to Study, by George F. Swain, L.L.D., Gordon McKay, Professor of Civil Engineering in Harvard University and Massachusetts Institute of Technology. Pages 65. 12×19 cm. Paper. Single copies, 25 cents. 1917. McGraw-Hill Book Co., Inc., New York.

While few students know how to study understandingly and efficiently, there has been little effort to teach them this most important lesson. This paper discusses under the topics, the proper mental attitude, studying understandingly, mental initiative, and habits of work, the necessity for hard work and the methods of working effectively. Though written for college students, all teachers and students will find it most helpful. H. E. C.

Plane and Solid Geometry, by Marquis J. Newell, Instructor in Mathematics, High School, Evanston, Ill., and George A. Harper, Instructor in Mathematics, High School, Kenilworth, Ill. Pages xii+384. 14×19 cm. 1917. Row, Peterson & Co., Chicago.

This book is the outgrowth of the long experience of two men in teaching geometry in the high school. They are well known as successful teachers and are exceptionally well prepared to write a book adapted to the needs and stage of development of pupils in the average high school.

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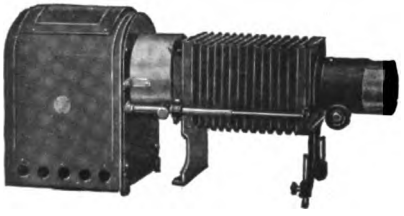

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SCHOOL SCIENCE AND MATHEMATICS

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THE SCIENCE ELEMENT IN EDUCATION.[1]

By L. H. BAILEY,
Ithaca, N. Y.

The address was divided into two general parts: First, an expression of opinion and point of view on the traditional division of educational topics into the arts and the sciences; second, the contribution of science teaching to the development of civic ideas, particularly to the achievement of democracy. On the old controversy between the humanities and the sciences, now again revived, he spoke as follows:

We are born to "things" and to "phenomena." We know things, smell them, wear them, handle them, see them. They comprise the goods of life. The phenomena represent the interplay of forces.

We cannot conceive of existence without things and phenomena. Even our conceptions of the state of immortality are imaginations of glorified material things, even to cities not made with hands. The life of the day is the life of experience with things. There is wood and objects made of wood; rocks and works in rock; land; trees, birds, quadrupeds, streams, hills; slants and levels and inclines; houses big and little; people; the sky; the light and the dark and the gloaming; machinery; food; fabrics wonderfully fashioned of many wonderful materials; ships and the sea under them; timeless shores; great cities and the vast accumulations in them; things that are and things that have been; action and reaction of materials and of forces; actions present and actions past; movement everywhere, quiescence everywhere; numbers and the relations of numbers; quantities; the human mind. The regulated knowledge of things and phenomena is science.

As we depend on things and phenomena, so is the science of them essential; and what is essential is necessarily educational, if we are to live rationally.

We have confused ourselves by explaining to ourselves that we understand. We build up philosophies on subjective processes, and depart from contact with the things and the phenomena about which we philosophize and psychologize.

We are given to the use of phrases and catch-words. We have said far too much of the value of some subjects as "discipline." We make unnecessary and untrue contrasts of "conventional" and "modern" subjects; of "humanities" and "the arts" and "the sciences." I doubt

[1] Abstract of address before the Central Association of Science and Mathematics Teachers, at Columbus, Ohio, November 30.

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whether the terminology represents essential differences, or means as much as we think it means.

In view of the experience in life, the effort to prove that educational values inhere somewhat exclusively in certain subjects becomes merely weariness. I think that all knowledge is good for the human mind. I have never known any education to hurt anybody, even though it is said to be poor education. Some educational effort is less effective than others because it is less organized, has less constitution, is founded on less knowledge, dominated by less sense, and propelled by a poorer teacher.

You will understand by these allusions that I am not to discuss educational values as such. Now and then we need to come back to science as science, as a knowledge and appreciation of the life we live. Here are the values that cannot be gainsaid.

I know of no line between science and non-science in education. I know of no "humanities" that are not science. I know of no "science" that is not humanities. If chemistry may be a means of effective education, so may history. Even tradition has educational value. for tradition is part of the natural history of the human race.

In this modern world of intense activity I have no fear of what we call tradition in education, although some of our writers seem to have made it a bogey-man. We might profit greatly by more tradition. It is a vast misfortune to separate ourselves so completely from the human past. We have forgotten our grandfathers and soon we shall forget our fathers.

Old subjects may be more worth while in the schoolroom than the new ones, because they carry with them much accumulated human interest; they may also be better organized as educational agencies: I should want them taught as live subjects, however, not as dead ones.

I deprecate the constant iteration of "science" and "humanities." If we were to cease this useless discussion, magnifying the differences, we should soon forget the division, for the division is arbitrary. Any subject is only what human beings make it, and of any two of the recognized subject-courses one is as humanistic and as cultural as the other were it possible for one teacher to teach the two subjects equally well. The greatest deficiency of the older line of subjects is the assumption that it is superior in itself and has more power of mental training: this attitude foreshortens the reach of the teacher and deprives him of the best approach to his pupil.

The greatest deficiency in the science line of subjects is the assumption that it is superior because it may have direct application to the arts of life: this attitude limits the range of the teacher and forestalls the full meaning of the subject. So completely do we advocate and justify science because of its application that we almost forget that the highest quest of mankind is to apprehend the truth. Recently I sat for two days hearing papers on many natural science subjects, mostly without application to current affairs. It was like a translation into a super-world, into a realm of high endeavor for the sake of the endeavor, beyond politics, commercial drives and compromises. No one paused to ask what it was for, what use it had, what anybody expected to gain by it, or what the public would think of it. I should have felt the same satisfaction had I sat for two days with a body of distinguished classicists. To state facts and conclusions because we think they are true and to let the truth be its own reward is reason enough.

This motive to know the truth and to interpret it is just as evident in what we call the humanities as in what we call the sciences. It com-

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prises a reason for education. It establishes the ideals in the young, for one cannot be right with oneself or be rectilinear in relations with one's fellows unless one thinks first of the integrities rather than the expediences.

This mental attitude and the intellectual cultivation may be derived from Greek or from geometry or from biology, although the color of the result will differ with the subject and particularly with the teacher and the atmosphere of the instruction. The different subjects develop their own mental aptitudes, one, as mathematics, the integrity of the mental process, another, as geology, accurate observation. Herein lies the great value of modern education, in the fact that we may secure the central result and at the same time stimulate the variation that develops the mind sympathetically and that opens it to the vast satisfactions of life. I would not want the pupil or the student to be educated in Greek alone or in geometry alone or in biology alone.

I do not like the course of study that is all of the kind that we loosely call "the classics"; no more do I like the course that is all of the kind that we call "natural science."

It is surely unnecessary for me to say that I hold also for the full educational value of science that is applied. Science is science, whether devoted to the uses of life or whether it rests as its own reward; science does not need justification; no knowledge needs justification; it is for this reason that we should make no classification of "pure" and (by implication) "impure" science, any more than we should perpetuate the fiction of humanities and science: one is able to appreciate science for the sake of science at the same time that one applauds the application of it to medicine and agriculture. No person should ever attempt to apply scientific investigation until he understands and values science for its truth in the abstract.

We are misled by our phrases.

The speaker pointed out that the differences between the arts courses and the science courses are kept alive in part by the departmentalizing of our education, whereby each department of subject matter may become, at least in colleges and universities, a sort of an independent monarchy presided over by one king. In the larger institutions of higher learning, the great lines are separated into distinct colleges with separate and more or less autonomous administrative heads. These separations make the subjects to appear as if naturally differentiated and distinct, whereas in nature there are no such clear divisions. For administrative purposes, it may always be necessary, particularly with the growth of institutions, to separate the parts and to name them; but we should devise some way or system whereby the pedagogical aims can be brought together and one subject be brought to bear on the other. The departments in life are not as distinct as the departments in schools.

We need harmony in educational purpose rather than separation and antagonism. Whether or not we can make any change in the departmentalizing, we certainly can be careful not to suggest to the pupil that there are two camps, two realms with

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divergent aims, a superior and an inferior kind of subject-matter. We can also stop all the weary discussion of "culture"; the word really contributes nothing but confusion to education. The war has shown us how dangerous it may be, in another language form as a password; we should now be ashamed to use it.

The second part of the address dealt with the place of science teaching in the development of personality and also of democratic ideas. It has recently been said that the teaching of science has resulted in the deterioration of character. So far as such evils have followed, it is not that science is inadequate to the highest results in human character, but rather that we have not yet learned how to use and to teach the vast treasures of fact and application that have overwhelmed us in recent times. Science is as capable of developing the higher moral and sentimental qualities as are the older subjects. We shall understand in due time that science is not merely a handmaiden to industry, but that it may expand the soul.

The speaker detailed some of the gains in intellectual poise and outlook that may come from a good teaching of natural science in the schools and higher institutions. He founded his discussion on the statement that the purpose of the quest of science is to find the fact and to know the truth. The truth is impartial, it invites a following to the logical conclusion; therfore, it trains directly in integrity of mind. The teaching of science stands always for the open mind. The man who prejudges or who starts with personal convictions does not become an investigator. He is more than likely to use the facts of science to uphold his own egotism; this is not science, however freely it may incorporate scientific facts into its processes. Science puts out no feelers to test public opinion. It is not dogmatic. It is not partisan, if its judgment is that of the open mind, seeking the truth. Undoubtedly very much of the spread of democracy in recent time is due directly to the teaching of science, whereby persons are taught to seek the fact before they draw their conclusions.

Science is never partial to any set of facts; it knows no "beliefs"; it is free to all men so far as they are able to understand; it is unselfish; it is adaptable to all persons, fitting their needs; in the quest of science there is no secrecy, no deals, no accommodations, no conspiracy, no favor, and no courtesy to high opinion that is not founded on rational investigation; the science method is not a secret method; it removes the fear of truth and

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the fear of dogma and the fear of nature. Science develops the individual, because every person makes his own investigation and takes nothing for granted. It makes directly for the independence of the voter and for stability in public opinion. It is revolutionizing agriculture; no longer do we plant in the moon and no more are we guided by the Babylonian signs. It is time to introduce into politics the attitude of the open mind, independent of party programs, to approach public questions in something of the spirit in which we approach the problems of science, desiring to know the facts, the situation, and to decide after we know rather than before The facts of science are not discovered by debate or by argument. Neither are we able to settle the tariff or any other public question by platform polemics. We need first the facts, and these are to be obtained only as the result of patient investigation by persons who are carefully trained and have no theories to establish. Without the spirit of science permeating the body politic, it is impossible to have a real democracy, for democracy is not a form of government, nor is it freedom, but a state of society that allows all citizens to partake and every one to develop his personality. Democracy cannot be bestowed; it can only be achieved.

GROUP RECITATION IN GEOMETRY.

By LENA B. HANSEN,
Kansas State Normal High School, Emporia, Kan.

The idea of the group recitation to supplement or take the place of the usual class recitation is not a new one. It has been used by a few teachers in various forms for some time. Laboratory work in which two or more students perform an experiment together, or mathematics classes in which several students solve some problem or problems together, were perhaps the earliest forms. Groups for discussing and correcting English themes and for practice in translation and conversation in foreign languages have more recently been used with success. E. E. Dodd, Principal of the Springfield, Mo., High School, has worked out a plan for group conversation in English beginning in the junior year of the high school The teachers who have tried his plan are enthusiastic over its success.

But there is perhaps no subject in the high school curriculum in which group recitation can be used so much or to such decided

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advantage as in geometry. One plan of group recitation in geometry is described by Professor S. C. Parker, of the University of Chicago, in his *Methods of Teaching in High Schools.* By this plan the class was divided into three sections according to ability, the brightest students forming one section, the medium students the second, and the slow students the third. The class was first well started as a whole, but when the members knew pretty well how to proceed and the teacher had had time to judge of their ability, then the division was made. One of the brightest students with teaching ability was put in charge of the first section permanently. A capable student from the second section was made monitor or captain of that group. Students from the two better groups were selected to take charge of the slow section for different intervals. These monitors or captains would thus be absent from their own sections a part of the time but the work missed was made up.

The groups recited at the same time in different parts of the room. Each section proceeded according to its ability; the first section completed plane and solid geometry in one year, the second completed plane, and the third about four books. Thus the good students were not held back by the slow ones, while the slow ones did not lose interest by being in a class with students with whom they were unable to keep pace. The slow students did thoroughly what they were able to do, instead of stumbling along, getting very little out of the work except a hatred for the subject. But this plan as the author says requires a very skillful teacher. The average teacher would find difficulty in keeping in close touch with, and directing, three distinct classes reciting at the same time.

A group plan which can be carried on with success by the average teacher has been used for several years by the writer. A number of other teachers have tried the plan and have reported that it has not been difficult to manage and that results were most gratifying. Three to five weeks are spent on construction work, experimental proofs, and simple field work in order to arouse interest and a demand for proofs. A few formal proofs are then taken up with the class as a whole. When most of the members know something of geometric procedure, the class is divided into groups of not more than five members in each. The divisions are not made on the basis of ability, as in the other plan, but a careful study is made of individual students, and groups are formed of those students who will probably

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work well together. These groups are, however, not permanent, but are changed wholly or in part quite frequently, particularly at the beginning. Occasionally for a short period, especially when reviews are given, groups of the brightest students are formed and more difficult original exercises are given to them. Groups of boys alone and of girls alone are formed at times for variety. Greater interest is stimulated by occasional contests between the groups to see which can accomplish the most in a given time. One of the members of each group is appointed leader, but every member of the class takes his turn at being leader sometime.

After a brief meeting of the class as a whole for discussion of some point of common interest, or for the development of some new idea and for the assignment of the lesson, the groups pass to the sections of the board assigned to them and the leaders take charge. The groups recite simultaneously as in the other plan but they keep together. At first the group work is carried on only two or three days a week, and the class recitation the other days, but as the students become more proficient and better able to handle the work, recitation by class as a whole becomes less frequent. The fact that the groups keep together, however, makes the plan easy to manage. At any time that the teacher desires he can have the usual recitation for the whole or a part of the period.

Assignment of the work to be done in each group is made either by outline put on the board by the teacher, when all the groups may do the same work, or by the cards containing propositions and exercises from the text and other sources. These cards are made a part of a permanent file and are used from year to year. They are marked so that they can be quite easily sorted out to be used when needed. Sometimes the leader makes the outline for the lesson of the day with some review work which he thinks his group especially needs. The extra cards containing the original exercises are used when this work is completed.

The leader calls on each member of the group to recite, and while one student recites another may write the principal steps of the proof. The leader or any other member of the group may ask to have some part repeated if he does not think it was made clear. If any member has a different proof he is asked to give it. Students are always encouraged to work out proofs of their own for their own propositions of the text as well as for the

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exercise. If a student fails he is asked to recite on the part he missed after it has been proved by another student, but he must use a different figure with different lettering. If all fail, they may work out a proof together, each contributing what he can. Sometimes very lively discussions will ensue, but this gives spice to the work. The leader must take his turn in reciting sometime during the recitation, but he can recite when he chooses so that even if the leader is a slow student he can usually find some part of the lesson with which he can do something and so is not humiliated by having to fail.

The teacher visits each group, listening, suggesting, asking questions here and there, and occasionally quizzing rapidly over parts the group has worked out in his absence. This is easily done if the principal steps of the proof are written and left until after the teacher's visit. Sometimes he may take a slow student aside for a while to help him clear up some point or he may ask some student with teaching ability for a part of the period.

The group is also very effective for out-of-door work in geometry. The instruments needed for this work are very simple and can easily be constructed by the students. Large wooden triangles, both isosceles and scalene, may be mounted on pedestals. Pins may be made, and if a good tape cannot be procured some heavy cord may be knotted in foot lengths. With these and a plumb bob a number of exercises may be worked out which not only add interest but make the students feel that the principles of geometry have some practical applications. After discussion as to methods of procedure by the class as a whole, the groups may solve problems as bisecting angles, making perpendicular offsets, dropping perpendiculars, laying off a line parallel to a line, finding the distance across a pond, the heights of buildings, computing areas of irregular plots, and other problems which will suggest themselves to the teacher. Two groups may solve the same problem by different methods, for example: one may find the height of a building by using an isosceles right triangle, another by using the scalene triangle. The next day they may explain the solution to the whole class and the methods and results may be compared.

For out-of-door work the best results are obtained by dividing the class into two or three groups. Teachers will find difficulty in supervising many groups working at some distance apart. But the smaller indoor groups may be assigned some field prob-

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lems to be solved without supervision and may report results. The number in the groups for indoor work is limited to five because it was found that more than that number did not work so well. Groups of three or four work well when the class is small, but with the average high school class of thirty or thirty-five this is practically an impossible arrangement.

The advantages of the group plan over the usual class recitation plan all of the time are many. The students recite to a more interested group and hence they are more interested. They get more practice in trying to reason as every student has an opportunity every day to contribute something to the recitation. They ask questions much more freely and get the practice in thinking out questions which are usually asked by the teacher. The teacher frequently consumes too much time and the students too little. The difficulties of the student are not always appreciated by the teacher in the class recitation, for the student often tries to conceal the fact that he does not understand, in his desire to appear well before the class. The recitation is too often a period in which the student recites what he has learned for the purpose of reciting. Even if a different point is explained by a bright student or by the teacher, and the teacher asks, "Is there anyone who does not understand?" the slow student and even some good students often pretend to understand rather than to appear stupid.

The group develops the student in initiative and leadership. By making him succeed, in some measure at least, it develops confidence, for there is nothing which so much succeeds in geometry as success. Once let the student feel the thrill of really having worked out something for himself and he will work with greater zeal to succeed another time.

The students enjoy this type of recitation so much more. They feel as if they are in a big workshop. They are more directly responsible for the success of the recitation and for the success of the members of the group. The lazy student is not allowed to shirk; the members of the group insist on each member doing his part. The group recitation fosters the spirit of helpfulness and cooperation. Students have volunteered to take turns in working extra time with slow students. They discover that a student is not helped by having things told him so they become resourceful in using illustrations and asking questions which will lead him to see for himself.

The group work, however, does make a bigger demand on the

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teacher, for he cannot just stand and ask questions, but must keep in close touch with all that is being done. But he comes to know his students better and to appreciate their strong and weak points better. The attitude of the class toward the teacher is more sympathetic; they feel that he is more of a friend and councilor than in the more formal recitation. The students realize that the recitation is a period of improvement and growth. Now and then some students will neglect preparing the lesson assignment before coming to class, but when this happens group privileges are taken away.

The classes using this plan have not only been able to complete plane geometry with all the exercises of a text like the Ford and Ammerman *Geometry*, but have solved many exercises from other sources. Of course all the students do not succeed equally well by this plan any more than by other plans, but even the slow students understand most of the work and solve a great many exercises. The classes have also done considerable work in out-of-door geometry besides having a number of program days. These programs, planned by different groups, assisted by the teacher, consisted of interesting bits of history, mathematical quotations, mathematical recreations, and debates on some such question as: "Resolved, That all mathematics in the high school should be elective." The programs were not confined to geometry, but interesting items from arithmetic, algebra, science, and invention were included.

Such programs may be made a big thing by giving the student a larger view of the subject. He may be given some insight into the marvelous system of the universe and learn something of the workings of mathematics in common things. He may be made to get some idea of the fertility of the human mind which through the application of the mathematical laws of nature makes our civilization possible and without which we would still be living in rude huts without our modern conveniences. This means more to him than the proving of so many theorems and exercises. However, the group recitation because of its economy of time makes it possible for the teacher to feel that he can do these things without slighting the others, and in fact through them create a stronger interest in the formal work of the class.

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PHYSICS IN THE HIGH SCHOOL.

By R. A. Burtnett,
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As the time for the study of physics is limited in practically all American high schools to one year, the diversified uses to which the knowledge gained in this course is to be put, the need for concentration and specialization in this subject to prepare the large percentage of college-going high school graduates for university technical courses, together with the ever-increasing subject matter in this course to be covered, especially in the field of electricity, are some of the causes which have made the thorough and adequate presentation of the subject extremely difficult.

Although four years of language are regularly taught in our high schools, and all admit that physics is just as important as language, boards have refused to consider more than one year being given to this subject, chiefly on account of administrative problems arising from the ever-increasing curricula.

Unless some rearrangement of our high school science courses and the time given to them can be made as suggested in the excellent plan outlined recently by R. A. Millikan and published in the May, 1917, issue of School Science and Mathematics, or until this plan can become formulated and placed in practice, many physics teachers may well consider what improvements they may introduce directly into their methods of presentation of this subject.

Simplification of the course as now presented may do well, for some of the most widely used books today are better as references than as texts, due to the fact that they are too profuse—made so in attempts at simplicity and lucidity—and are written by mature minds which have forgotten the workings of themselves at the ages of seventeen and eighteen. Some of the more recent texts from the press are tending too much in the opposite direction, however, are too nonmathematical, and have sacrificed too many scientific principles to make way for superfluous practical applications and illustrations.

Let the physics omit such formulas as:

$$OF = OC \times 9/5 + 32$$
$$R = K\,L/A$$
$$PV = K$$
$$\text{and } HP = f\,s/33{,}000\,t.$$

Formulas of this type are seldom really understood by the majority of a class, and their meaning would seldom be recognized

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a year later. They are a hindrance to the understanding of the subject by the student and to the application of reasoning principles which the course is supposed to develop. They *may* be understood for the time being, but as such are only instruments to be remembered, and who wishes to have the student draw from his memory tools which will work only if used in the right place in preference to the application of principles which he has studied, had presented in the classroom, and verified in the laboratory? The very mental reasoning processes which a student must use in the solution of any problem carries him through the mathematical operations of the formula which has been generalized in symbols, and in which, if used, he is instructed to substitute, blindly, without any special reasoning whatever. The value of the knowledge of the principles of science lies in the complete understanding of those principles and the significance of their application, and the understanding may be made more complete by the applications to numerous and varied problems than by the single application of the principle to construct an expressionless formula to be used mechanically thereafter. All formulas cannot be eliminated from the course, and this is most certainly not desirable, but many of the above type may be eliminated, and the remainder may better be presented in emphasized lecture and laboratory form than from text assignments.

In simplifying the course the elimination of some material might be considered, yet what to eliminate would be hard to decide. Undoubtedly, in a few years we will be living under the metric system, and then most certainly the study thereof shall not be a part of the subject matter of physics, and thus some relief afforded. Not only would time be saved due to the fact that it would not be necessary to teach this system, but also much waste would be eliminated if students went into the laboratory at the beginning of the year with a thorough understanding of and complete familiarity with the units of weight and measurement which they were to use throughout the year. In after war commerce, when English-speaking peoples will be seeking to supply the markets of the world with manufactured products, the metric system if adopted would prove of great benefit. Arguments from too many points of view have recently been printed[1] to mention any further here. Metric measurements may soon come to be taught in elementary

[1]Vol. IV., No. 3, *Scientific Monthly*.

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arithmetic, eliminating the necessity of time used in this study in the high school.

Every physics teacher who uses any other text than his own, and having as he does his own specialties, can better present them in a clear-cut form by lecture than by any amount or kind of assignment. This applies to the principles of the subject matter, and not to the whole body of it. Other points that the physics teacher should not neglect in his lectures are those which most authors have neglected; the welding together of the parts of the text dealing with different subject matter based upon seemingly entirely different phenomena. There should be unity and complete coherence.

With a view to this accomplishment, the following order for taking up the work throughout the year is suggested. The divisions are not to be made isolated chapters.

I. Molecular Force and Motion.
II. Mechanics of Fluids.
III. Force and Motion, Work and Energy.
IV. Heat.
V. Magnetism.
VI. Electrostatics.
VII. Current Electricity and Accompanying Magnetic, Heating, and Chemical Phenomena. Induced Currents.
VIII. Light.
IX. Sound.

With all respect for coherence, no difficulty in transition should be encountered until the end of the third division, and there certainly is the place for emphasizing the Law of Joule of heat-work equivalent. Heat and magnetism are both molecular phenomena. The electric current has been admirably defined as "an electric charge in motion, whose presence is most usually detected by the magnetic effect which it produces." This one good tie binds permanently V, VI, and VII. The heating effect of the electric current offers a further linkage with the preceding, through the relation between the electrical unit of work, the watt second, and the calorie. The electromagnetic theory of light reaches out to VIII, and the main variation in IX is the fact that there the vibratory motion takes place in the air medium.

If it can be impressed upon the young mind during the period of training in the rudiments of science that the workings of nature are based upon sets of laws which are interlinked and correlated rather than distantly related, then certainly any additional effort put forward to this end will be worth its investment.

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VALID AIMS AND PURPOSES FOR THE STUDY OF MATHEMATICS IN SECONDARY SCHOOLS.

By ALFRED DAVIS,

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Chairman of a Committee of the Mathematics Club of Chicago Appointed to Investigate This Topic.

It is our purpose in making this report to aid the National Committee of the Mathematical Association of America in investigating the reasons for the teaching of mathematics in our secondary schools. The topic is a vital one, since its consideration must determine the place and the nature of the mathematics taught in our high schools. Its discussion is timely, since the challenge has come from various sources to us, as teachers of mathematics, to defend our subjects, especially algebra and geometry. Educational inertia will no longer protect us. A passive attitude is no longer tenable; we must make our position clear. Even though we have little that is new by way of argument to offer; and even though we prove nothing beyond the possibility of a question, a statement of what we are convinced is true cannot fail to be of value both to teachers and to laymen whom it may reach. Since it is desirable, if possible, to avoid every generalization not supported by the results of scientific investigation or by the highest philosophic authority, we shall, throughout the discussion, make generous use of the investigations of others and shall quote freely from those who can speak with authority. We make bold to do this because important statements and valuable work increase in importance with emphasis and use. In the words of Dr. Smith, of Teachers College, when speaking of philosophers of standing and of those who are masters in their respective fields of effort, "These after all are the men who are our leaders."

PART I.

The study and the teaching of mathematics in our secondary schools may be justified under the following heads, and it is to these that we may turn to establish the validity of our aims and purposes:

1. *Philosophy.*
2. *Psychology and Its Experiments.*
3. *Experience.*
4. *The Utility of Mathematics*

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1. Philosophers from Plato to the present time have been almost unanimous in their approval of mathematical studies. They believe that culture and mental discipline result from their pursuit. These are men to whom we must listen. They are masters in the art of reasoning and arrive at conclusions free from sentiment or prejudice. Where exceptions occur, it is usually due to a lack of knowledge of mathematics and a consequent inability to judge. The famous criticism of Sir William Hamilton has no weight, since John Stuart Mill ("Examination of Sir Wm. Hamilton's Philosophy," p. 607) shows that Hamilton did not know mathematics; and Professor C. J. Keyser (in an address at Columbia University, October 16, 1907) shows that he was prompted by unworthy motives. Oliver Wendell Holmes and Thomas Huxley were sincere in their doubts as to the value of the study of mathematics, but these have been ably answered by J. J. Sylvester and C. J. Keyser. Professor A. N. Whitehead ("Introduction to Mathematics," p. 113) says, "Philosophers, when they have possessed a thorough knowledge of mathematics, have been among those who have enriched the science with some of its best ideas. On the other hand it must be said that, with hardly an exception, all the remarks on mathematics made by those philosophers who have possessed a slight or hasty and late-acquired knowledge of it are entirely worthless, being either trivial or wrong." Philosophy's support of mathematics stands like the rock of Gibralter, secure amid the passing assaults made against it.

Plato, "Let no one ignorant of geometry enter my door."

August Comte, "No irrational exaggeration of the claims of mathematics can ever deprive that part of philosophy of the property of being the natural basis of all logical education, through its simplicity, abstractness, generality, and freedom from disturbance by human passion. There, and there alone, we find in full development the art of reasoning, all the resources of which, from the most spontaneous to the most sublime, are continually applied with far more variety and fruitfulness than elsewhere. . . . The more abstract portions of mathematics may in fact be regarded as an immense repository of logical resources, ready for use in scientific deduction and coordination."

G. Stanley Hall, "Mathematics is the ideal and norm of all careful thinking."

2. It was but yesterday that psychologists denied the transfer of training, and so to them the ability acquired in the study

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of mathematics was of value only in the further study of mathematics. This position has not been successfully defended. Professor Smith, of Columbia, says, "The attack upon mathematics, that it has no general disciplinary value, has thus far been abortive scientifically. We have only to note how divergent are the results of various investigations to see the truth of the assertion." Professor G. M. Stratton, of the University of California ("School and Society") says, "It is a grave mistake to suppose that the experimental work has proved that the idea of mental discipline is no longer tenable." Today all psychologists of standing concede transfer. The only questions are as to how much, and by what agencies it is accomplished. Is it not probable that tomorrow all doubts regarding the mental transfer of training will have run their course and will be dead, at least for a time?

It would be of interest to show that questionable results have been obtained, and that undue importance has been attached to experiments worked out by psychologists and others, in attempting to show that the value of the study of mathematics has been exaggerated. Indeed, when we consider that these experiments are likely to be limited in scope; that the material to be experimented with (human minds) is almost infinite in possible variety; and that the interpretation of results is largely an individual matter; we must concede that such efforts are of doubtful value. However, psychology and its experiments in relation to the teaching of mathematics is to be considered by another committee.

3. The experience of the race justifies the teaching of mathematics. This is almost too obvious to need mention. Civilization may be measured in terms of mathematical progress. Mathematics is the ladder, giving the sure footing, by which we have climbed steadily to higher levels of achievment. It is through mathematics that man has been able to strip mystery from the forces in nature and to harness them for his service. Colonel F. W. Parker ("Talks on Pedagogics," p. 92) says, "The lower the grade of development in the human race the less there is known of number." Mathematics is then an intrinsic element in human progress. Scientific progress is impossible without it. It is interwoven in the fabric of our commercial and industrial life. Since this is true it must change as the race advances—perhaps slowly—but ever to increase the importance of its study.

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4. The direct practical utility of mathematics alone will not justify our present high school courses in the subject. To many earnest and sincere critics mathematics is only a tool invented by man for the mastery of other fields. In fact, this is the rock on which most of those who object to mathematics shipwreck. Mathematics is vastly more than a tool; it is a type of thought, and even high school students gain indispensable training in mental activities from it—such training as cannot be gained so well from any other study. Professor C. J. Keyser ("The New Infinite and the Old Theology") says, "Mathematics is indeed a humble servant—a drudge, if you please; an unsurpassed drudge—in the sense that nothing else does a larger share of humble and homely work. To imagine, however, that her place in the hierarchy of knowledges is thereby defined is hardly the beginning of wisdom in the matter. It is necessary to look much higher. Her rank in the ascending scale is not that of a useful drudge, immeasurable as is her service in that capacity; it is not merely the rank of a metric and computatory art, invaluable as the latter is, as well in science as in the affairs of a workaday world; it is not even that of a servant to other sciences in their fields of experimental and observational research, indispensable as mathematics is in that regard; over and above these things, she is charged with a sacred guardianship—in her keeping are certain ideals, the ideal forms of science and the standards of perfect thinking; she is concerned not with the vagaries, but with the verities of thought, with select matters independent of opinion, passion, accident, and will; it is thus peculiarly hers to release human faculties from the dominion of sense by winning allegiance to things that abide; her meditations transcend the accidents of time and place; it is their idiosyncrasy to have for subject proper, not the fickle and transitory elements in the stream of a flowing world, but those aspects of being that present themselves under the forms of the infinite and eternal." The tendency today is to overemphasize the utility of all high school studies. Professor John Dewey ("How We Think," p. 138) says, "There is such a thing, even from the commonsense standpoint, as being 'too practical,' as being so intent upon the immediately practical as not to see beyond the end of one's nose or as cutting off the limb upon which one is sitting. . . . Exclusive preoccupation, with matters of use and application, so narrows the horizon as in the long run to defeat itself. It does not pay to tether one's thoughts to the post of

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use with too short a rope. Power in action requires some largeness and imaginativeness of vision. Men must at least have enough interest in thinking to escape the limits of routine and custom. Interest in knowledge for the sake of knowledge, in thinking for the sake of the free play of thought, is necessary then to the *emancipation* of practical life—to make it rich and progressive." Lord Beaconsfield's definition of a practical man is too often the truth: "A practical man is one who practices the errors of his forefathers."

Many today make the mistake of measuring educational values in terms of money. They would prepare the child merely to get the necessaries of life. These are the enemies of liberal education; for if such are our aims we are, as a people, in the process of decay. The aim of education should be to make lives worth preserving—lives that will, at least in some small measure, make the world a better place in which to live. But multitudes of men and women "like dumb driven cattle" go wearily to toil each day. They use the last measure of strength in earning a livelihood—beyond this they have no vision. If they seem satisfied it is because they lack the outlook on life which an education ought to give. There is danger that educators will assume that people need training for efficiency *in* this sort of life, but such is not the vision of leadership. These people need the best possible education, as much of it as they can get; not an education in any sense inferior, or suited to an inferior station in life. Professor Keyser (*Educational Review*, April, 1917) says, "I desire to warn you, as a friend, against the enemies of liberal education. These are very numerous, being easy to produce, springing up like weeds along the dusty highway, almost under the very hoof of travel. I desire to warn you against the insidious and baleful influence of omnipresent, well-meaning, wingless-minded educators who unconsciously conceive young men and women as more or less sublimated beasts; and who regard colleges and universities as agencies for teaching the animals the arts of getting shelter and raiment and food." The motto of the Pythagorean Brotherhood should be the motto of today,

"A figure and a step onward:
Not a figure and a florin."

Yet the study of mathematics will ever be important from the standpoint of utility. Geometry originated in Egypt from the need to survey the farms in the valley of the Nile, and to replace the landmarks swept away by the periodic overflow of the river.

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Any schoolboy knows that algebra enables us to solve problems which are practically impossible of solution by arithmetic. The invention of the calculus enabled Newton to apply his law of gravitation to the motions of the planets. As needs have arisen in various fields, mathematics have been invented to relate theory to fact. Discoveries have been made in pure mathematics, when studied for its own sake, and later these have been applied to practical ends. There are many fields in which a knowledge of mathematics is absolutely essential to their mastery; indeed, it seems to be necessary to all branches of knowledge as these become more complete and so more scientific. Dr. O. J. Lee, of Yerkes Observatory, calls attention to the fact that many astronomers, while in the opinion of the outside world successful, have failed from lack of a sufficient foundation in mathematics. The same is true of many other lines of effort. Professor J. W. A. Young ("The Teaching of Mathematics") says, "For direct practical usefulness, mathematics is second only to the mother tongue." Regarding the possible future of mathematics in this line, G. St. L. Carson ("Mathematical Education," p. 51) says, "I believe that the modern theories of pure mathematics are destined to illumine our understanding of the human mind and of cities and nations, just as the pure mathematics of fifty years ago has already illumined the previously dark and chaotic field of physical science; that modern mathematics is or will be to psychology, history, sociology, and economics as has been the older mathematics to electricity, heat, light, and other branches of physical science."

It is evident that the study of mathematics is amply justified by the testimony of philosophers who know; by its importance as an aid in mental development; by the weight of human experience; and because of its increasing utility. Mathematics is an essential part of any scheme of education that pretends to be well balanced or complete. Since the education of a rapidly increasing number of people ends with the high school, it must be taught there. What, then, may we hope to accomplish by its study?

PART II.

The aims and purposes which may be realized in the study of mathematics are determined by its values to the one who studies it. These possible values are almost without number. We shall consider some of the more important.

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1. *Mathematics Teaches Logical Thinking.*

It is the most effective means for teaching logical thinking aside from the actual study of logic; in this it is unique. Everyone needs this training and no other high school study can give it so well. John S. Mill ("System of Logic," Bk. 3, chap. 24, sec. 9) says, "The value of mathematical instruction as a preparation for those more difficult investigations consists in the applicability not of its doctrines but of its methods. Mathematics will ever remain the past perfect type of the deductive method in general." Benjamin Pierce (*American Journal of Mathematics*, vol. 4, p. 97) says, "Mathematics is the science which draws necessary conclusions." The type of reasoning most emphasized in mathematics is the deductive. This sort of reasoning is used in other subjects and is applicable to all sorts of situations in life. Deduction is the process of arriving at a logical inference based on accepted premises. Psychologists claim that all thinking is problem solving. The process as outlined by Professor Thorndike, of Teachers College, is as follows:

1. A clear statement of the goal aimed at.
2. The selection of enough and representative individual facts.
3. Their arrangement in such a way as to make the general idea or judgment to which they lead obvious.
4. The verification of the conclusion by an appeal to known facts.
5. Its reinforcement and clarification by exercises in applying it to new individual facts.

It is evident that the study of mathematics gives training in this process. The committee on Secondary Mathematics, appointed by the New England Association of Teachers of Mathematics, says, "Whatever one's occupation, it will be fundamentally important to have acquired in youth the habit of exact, orderly and logical thinking, which, if the experience of many centuries of teaching can be trusted, is best acquired by most high school students in mathematics well taught." Mathematics is, then, of first rank among high school studies in teaching pupils how to think. Its fundamental concepts are few in number, very simple, and lie close to the experience of the pupil. It should therefore be an easy study for any normal mind. John Locke ("Conduct of the Understanding") says, "Would you have a man reason well, you must use him to it

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betimes. Exercise his mind in observing the connection between ideas and following them in train. Nothing does this better than mathematics, which, therefore, I think should be taught to all who have the time and opportunity, not so much to make them mathematicians, as to make them reasonable creatures. . . . In all sorts of reasoning, every simple argument should be managed as a mathematical demonstration."

2. *Mathematics Creates Self-Confidence.*

This is not the confidence that makes "fools step in where angels fear to tread"; but a confidence based on that self-knowledge, and on that self-command which give poise and power. The gaining of this confidence is a necessary part of the early education of every individual, and it can be accomplished better by mathematics than by any other study. Other subjects depend on authority, and there is usually a difference between authorities and a conflict of opinions. The student is frequently bewildered. He wonders which authority to accept, and he doubts his ability to think out a conclusion of his own. He finds mathematics different. In mathematics there is no such thing as an outside authority: given certain premises, there can be no doubt about the results of his reasoning. Results are either right or wrong and they can be checked: algebra by arithmetical calculation, geometry by actual measurement. The reasoning of a student who lacks ability to study mathematics, or who lacks training in it, is likely to be of doubtful value—he is likely to be uncertain of it himself.

If mathematics has been properly taught and thoroughly mastered, one will not place too much dependence on the opinions of others. In this way its study will make for a better citizenship. The mastery of mathematics must insure the presence in a man of those qualities, at least some measure of them, which make leaders. The success of a democratic government depends on the power of its people to think intelligently and to act wisely. Sir James Bryce says, "It is by the best minds that nations win and retain leadership. No pains can be too great that are spent on developing such minds to the finest point of efficiency." It is equally true that no pains are too great that will raise the intelligence of the mass of the people to greater efficiency. It is economy to use mathematics as a means to these ends. The life of Lincoln illustrates this. In the "Life of Lincoln," Nicolay and Hay, vol. 1, p. 229, we read: "It was at this time that he gave notable proof of his unusual

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powers of mental discipline. His wider knowledge of men and things, acquired by contact with the great world, had shown him a certain lack in himself of the power of close and sustained reasoning. To remedy this defect, he applied himself, after his return from Congress, to such works upon logic and mathematics as he fancied would be serviceable. Devoting himself with dogged energy to the task in hand, he soon learned by heart six books of the propositions of Euclid, and he retained throughout life an intimate knowledge of the principles they contain." This is not an isolated case; others give testimony to the value of the study of mathematics in giving power to direct men on important issues.

3. *Mathematics Cultivates the Power of Concentration.*

The success of a student depends on his early gaining of the power to concentrate his mind on a given problem. To work with the highest efficiency the mind must be wholly absorbed with the task in hand, the nerves tense, and the body in an attitude that suggests attention and alertness. The easy-chair loafing method will not lead to a trained and developed mind. The pupil whose mind goes "wool-gathering" in the midst of important work, or who is easily distracted by his surroundings, is a failure as a student. This power to study is developed by mathematics as by few other studies. While apparent progress might be made in some studies without it, concentration is vital in this study. *The New England Report* says, "The real development of mankind lies in the growth of voluntary attention, which is not passively attracted, but turns actively to that which is important, significant, and valuable in itself. No one is born with such power. It has to be trained and educated. This great function of education is too often neglected." We are inclined to forget that real progress is directly proportional to the conscious effort of the individual. Prof. W. C. Bagley, of Teachers College, says, "Bricks cannot be made without straw, nor can mental growth be achieved without individual effort and individual sacrifice." Work is not play and the child must distinguish between the two. Something must be done besides amusing our pupils in class. There is something more important than catering to the child's wishes. Sometimes he may have duties to perform that he will not like. He needs the training that such effort will give, since he must learn to adjust himself to environment, and to the comfort and wishes of others as well as of himself.

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Spencer defined the educated being as one who did what he ought, when he ought, whether he wanted to or not. The pupil must learn that the world does not revolve about himself; and we as teachers should recognize the fact that a pupil does not find himself educated without knowing how it happened. Mathematics has the power to develop concentration; and it is our duty to furnish adequate motive for the effort that will accomplish this result. Professor R. E. Moritz (University of Washington) says, "That mathematics is the most efficient agency for acquiring the power of quick attention and prolonged concentration of mind has never been seriously questioned by competent critics." Prof. Gonzales Lodge, of Teachers College (Address before the faculty of Teachers College, February 8, 1917) says, "It is apparently becoming more and more a cardinal doctrine of the shallow thinkers of the present day and generation that the mind of man cannot be trained; that the only thing that can be trained is the hand. . . . It seems to me axiomatic that mental training to be valuable must involve effort. . . . I mean that kind of effort, necessary in the development of the attitude of mind that faces a problem squarely, which goes to work at it in detail, which analyzes it with care and exactness; which expresses the results of this analysis with the same care and exactness. The mind that can do that is certainly a trained mind, and the benefits of such training are available in every walk of life."

4. *Mathematics Demands Originality in Its Study.*

It is probable that much of our school work stifles initiative and originality, if it does not kill these outright, in attempting to fashion large class groups according to one mould. This deplorable condition is aggravated by the excessive dependence on the text and the memory work so common in all studies. If the pupil can make a show of learning by repeating other people's ideas he is passed on and the teacher is counted a success. Mathematics, properly taught, and especially in its application to well chosen practical problems, requires independent thought and judgment. The pupil is able to realize all the joy of individual discovery and achievement, which is in itself a sufficient motive for the study of any subject. His new consciousness of independence and of power is an inspiration and a delight to a reasonably keen-minded student and is frequently a stimulus to a slower mind. Mathematics is usually the child's first introduction to the possibility of independent

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thinking; and at a time when the independence of maturity should be developing, it is especially suited to his needs. However, it sometimes happens that a child's ability to remember and to repeat glibly is mistaken for ability to think. Consequently a "bright" pupil fails in mathematics and the subject or the teacher is condemned by disappointed parents. To say that the study of mathematics does not develop originality, or to teach it as a thing to be learned by rote and to be applied by machine methods, is to debase it to the rank of a mere tool and create the possibility that a show of learning may be made by a mere exercise of the memory. There can be little gain for the pupil in either case. J. J. Sylvester ("Mathematical Papers") says, "As the prerogative of natural science is to cultivate a taste for observation, so that of mathematics is, almost from the starting point, to stimulate the faculty of invention."

Again, some students may possess unusual abilities in mathematics or in related fields. A lack of a knowledge of algebra and geometry in early years may mean that these will remain forever buried and that the race may be deprived of an important possible contribution to its progress. Even unusual difficulties with these subjects is not always a sufficient reason for the abandonment of them. Dr. Smith (*Mathematics Teacher*, March, 1913) speaks of some of the world's greatest mathematicians as being unpromising in early years. Florian Cajori ("A History of Mathematics," p. 201) says of Newton, "At first he seems to have been very inattentive to his studies and of very low rank in school." The study of mathematics will, then, draw out the individual powers of the pupil and enable him to "find" himself. It furnishes the best measuring rod for a pupil's abilities and needs.

5. *Mathematics Trains in the Precise Use of English.*

Teachers of algebra and geometry know that students have the greatest difficulties with translation problems in algebra and with originals in geometry. Most of the trouble is due to inability to read intelligently. Reading, of course, means getting the thought. Much of the pupil's reading up to this point has been so simple as to require little effort to get the meaning, or it may have been the mere repetition of words. The pupil must be taught to dig below the surface, to properly balance statements and to get their real meaning. The pupil must also learn to express himself in a concise and forceful manner.

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Definitions must be clearly and accurately stated, not a word too many, not a word lacking, just the right word for each idea. Hypotheses must be stated exactly and kept distinct from conclusions to be reached. All of this is hard work and requires much patience, but it is a worthy effort for both teacher and student. English teachers who have had the opportunity to observe are emphatic in their approval of mathematics as an aid in the mastery of English, correcting slovenliness and inaccuracy.

Much useless discussion and controversy would be avoided if the precise use of English were made a more direct aim in the study of mathematics. Professor Moritz says, "In mathematics, therefore, the student can be brought to recognize the absolute necessity of mastering the meaning of words preliminary to their use as a vehicle of thought. Half of the misunderstandings and futile controversies in active life arise from ambiguity in the use of words. . . . Mathematics has come to be accepted as the synonym for exactness, clearness, certainty." Perhaps in no other field is this training more essential than in the practice of law. Demonstrating before a class and answering questions from teacher and fellow pupils gives self-possession, ability to think on one's feet, and the power to adjust in proper order the important parts of any problem, giving to each its proper weight, so that desired ends may be attained. The pupil thus acquires ability to discuss a problem intelligently before a critical audience. Thomas Jefferson was of the opinion that, "mathematical reasoning and deductions are a fine preparation for investigating the abstruse speculations of the law."

6. *Mathematics Trains in Accuracy.*

Probably no other subject demands this quality to so great a degree. There is no opportunity to cloak errors with results "nearly" right. If approximate results are sought the limits for the errors are known. Pupils can judge for themselves and make their own corrections. Again, carelessness in securing data or in the drawing of a figure may vitiate the whole problem, no matter how perfect the reasoning. Furthermore, neatness is an essential part of accuracy and both should be conscious aims of both teacher and pupil. They should be emphasized more than at present in our teaching of mathematics.

(To be continued)

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HOW SCHOOL GARDENS TEND TO DIRECT A NATURAL COURSE IN BOTANY.

By Genevieve Monsch,
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(*Continued from January number*)

Sixth Week.

Because of their intense interest in their gardens, these children were always ready to talk seeds, seeds, seeds, and from the very beginning they were expressing their wonder and their surprise to find how much "a little lifeless seed" could do. They were constantly interested in watching the bees and the butterflies about the lilacs and the hyacinths, and they were constantly reminded of the story of pollination. It had become a habit early in our work to search for the pollen and the pollen boxes, the immature seeds and seed boxes in every flower available, and they were exceedingly delighted when one of the boys had finally discovered both pollen and seeds in such bisexual flowers as the willow and the strawberry after the class had begged for a week or more to be told about them. The morphology of the flower with the functions of each part was one of the easiest things that I had to teach in this course, simply because, I believe, the class was ready for such work. They had come in contact with such a large amount of material which had illustrated over and over again, pistil, seed box, seeds, pollen and pollen boxes, petals, sepals, etc., that they could enter into very intelligent discussions of the work. Even the subject of fertilization was not beyond these seventh grade youngsters although I will admit I *have* sometimes found it beyond high school pupils, and I have even known some college botany students who do not have as clear an insight into these processes as this little class had. I attribute it entirely to the interest these little people evinced in growing a few vegetables and flowers for their own use, because this very interest and the work itself brought them into daily contact with a large mass of living material.

Seventh Week.

Seed Dispersal. (Field trip.)

1. Wind
   - Downy seeds—old cat-tails, milkweeds, etc., dandelion, willow, poplar.
   - Winged seeds—maple, parsnip.
   - Small seeds—ferns, violets, lettuce, carrots, portulaca, pigweed.
   - Tumble-weeds—whole plant carried.
2. Animals
   - Burrs.
   - Acorns and nuts—sprouting or stored.
   - Berries—strawberries, old rose-hips, etc.

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3. Water { Water plants. / Algae spores. / Land plant seeds.
4. Discharge { Touch-me-not. / Violet and pansy. / Castor bean. / Witch-hazel. / Wild bean. / Primrose.

Freezing Action on Nuts, Wild Cucumbers, etc.
Why best to plant wild cucumber seeds, etc., in fall?

Seventh Week.

The subject of seed dispersal was approached principally through their fight against weeds, which of course were constantly bobbing up both in the gardens and in the grass and among the shrubs of the school park and, of course, everywhere else. *Our* worst weeds are dandelions, milkweeds, wild lettuce, tumble weeks, potentilla, burrs, pigweed, primrose, etc., and if you take the trouble to look at this list carefully you will see that it covers the principal methods of seed distribution. Moreover, we have preserved in large jars at least a hundred different kinds of seeds, most of which are garden seeds but many of which are weed seeds, treasured up for just such times as these. To these were added specimens of seeds and fruits brought in by members of the class. Some of these specimens (cat-tails, burrs, rose-hips, tumble-weed, fruiting-fern, etc.) were remains of the year before, while others (dandelion, willows, etc.) were just maturing, and scattering their hordes of seeds.

Eighth Week.

I. Field Trip to Study:
   1. Hydrophytes:
      a. Submerged entirely—spirogyra, mesocarpus.
      b. Submerged partly, or swamp-plants—cattails, iris.
      c. Free floating—marsh-marigold, cress, utricularia.
   2. Xerophytes or drought plants—cactus, pteris.
   3. Mesophytes or ordinary land plants, such as all those in school gardens and school park.

II. Water in Soils:
   1. Free water (swamps, etc.).
   2. Water of adhesion (mesophyticareos).
   3. Capillary attraction (experiment with lamp chimneys).
   4. Tillage. (Why so often?)

III. Uses of Water to Plants:
   1. Absorption.
   2. Germination.
   3. Conduction.
   4. Transpiration (transpiration experiments).
   5. Water storage—cactus, bulbs, sphagnum moss.
   6. Currents of water distribute seeds, spores, bacteria, whole algae, etc.
   7. Prevention of floods by forests.
   8. Photosynthesis, digestion, assimilation.

Note: Amount of water in soil is to be emphasized here. Splendid place for studying general adaptations to extreme conditions!

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Eighth Week.

Certainly it is not necessary to dwell upon this work of the eighth week. We are fortunate in having large, interesting swamps and hot, sandy, arid regions within a block of school. The children are very familiar with these regions, for they are typical of the whole of Gary, and "water plants," "drought plants," and "medium plants" are all well known and most eagerly described, and easily classified according to habitat. We had just one field trip for this subject but we were sure to include in our indoor discussion the retentiveness of soils regarding water, as well as questions of free water and water of adhesion, capillary attraction in soil, etc. This brought up the question of tillage again and of dry mulches, etc., and then, because we still had time, we discussed the uses of water to a plant, and on the blackboard we worked out the diagram shown above.

Ninth Week.

Roots:

1. Water roots—bulbs, cress, cuttings.
2. Prop roots—corn, palms.
3. Clinging roots—English ivy, ampelopsis veitchii.
4. Air roots—orchids.
5. Soil roots:
   a. Tap roots—carrots, cabbage, radish, pigweed.
   b. Fibrous roots—clover, grass, corn, peas, onion.
   c. Clustered roots—dahlia, sweet potato.
6. Parasitic roots—dodder.

Functions of soil roots, water roots, etc.?

Ninth Week.

The work of the ninth week is so simple that the outline shown here must explain itself. Cuttings of coleus, oleander, wandering Jew, etc., are constantly standing in the laboratory, and their delicate, interesting water roots are constantly questioned and discussed. Water bulbs are purposely dragged over until June. Water roots may have been a new subject in class but certainly it was an old subject in each individual's experience.

On the school building we had English ivy, Virginia creeper, and ampelopsis veitchii just starting up the walls, so that clinging roots were never confused with tendrils, as is often the tendency in classes of elementary botany.

Soil roots needed little explanation with this section of children. They had separated and planted over a bushel of the fleshy clustered dahlia roots and had eaten dozens of the tap roots of radishes from their own gardens and had carried on a constant warfare against weeds that were illustrating either tap

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or fibrous roots. Children see these things, and when properly interested will continually carry on their investigations of their own accord.

Fortunately for the botany teacher who deals with parasitism, we have loads of dodder all about us, usually infesting the willows of our woods, and twice they have caused a great deal of damage in some of our most beautiful beds of nasturtium. All of these children know dodder and all of them can tell you how its parasitic roots bore down into another plant to steal food which it cannot manufacture for itself.

Air roots are always strangers to most of these children. Some few children who have visited Lincoln Park can tell about the roots of the orchids that have been pointed out to them there, and then there are always pictures for the rest to see. That is the best we can do, but there is an intense interest here because of its relation and association with the other types of roots with which they are so familiar.

Tenth Week.

Stems:

I. Aerial stems:
   1. Climbing:
      a. Twining—honeysuckle, wistaria, morning glory.
      b. Tendrils—wild cucumber, peas, ampelopsis cinquefolia.
      c. Suckers—English ivy, ampelopsis veitchii.
      d. Petioles twist—clematis, nasturtium.
      e. Thorns—rose.
   2. Prostrate stems—wandering Jew, melons, strawberry runners.
   3. Erect stems:
      a. Branched—trees, bushes.
      b. Unbranched—sunflower, corn, canna, golden rod.

II. Underground stems:
   1. Bulbs—onion, tulip, etc.
   2. Tubers—potato, Mexican potato.
   3. Corms—gladiolus, crocus, Jack-in-the-pulpit.
   4. Rootstocks—violet, fern, lily-of-the-valley, square stem of mint.

Tenth Week.

If you look carefully over this outline for this tenth and last week's work you will see that it deals only with such material as the children have been dealing with and working with for ten long weeks—material which has become to them as familiar as the very members of their own class. Moreover, the garden displays all of this material in large numbers. For instance, all of the climbing and the prostrate stems mentioned, and many others besides, are found over and over again in our school gardens—all except the clematis, of which we have but two large vines. The underground stems, too, had been planted

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and were growing in large quantities. Hundreds of onions had been planted and grown and eaten and numerous crocus-corms and Dutch bulbs of all kinds had been removed. About two hundred corms of gladioli, a half-bushel of potato tubers, two bushels of the fascicled roots of dahlia, dozens of lily-of-the-valley root stocks and Mexican potato tubers had been handled. That is the only reason why this work seemed so simple to these boys and girls.

Conclusion.

Sequence in Textbooks.

Seeds and Flowers.

1. Morphology of flowers.
2. Pollination.
3. Fertilization.
4. Seeds (and fruits).
5. Seeds:
   - a. Embryo.
   - b. Monocotyledons or cotyledons
   - c. Kinds of food (reserve material).
   - d. Seed coats.
   - e. Conditions for germination (temperature, moisture, air).
   - f. Types of seedlings:
     - Dicotyledons:
       - Cotyledons underground—pea, oak.
       - Cotyledons above ground—bean, squash, morning-glory, radish.
     - Monocotyledons:
       - Cotyledons as well as coat brought above ground—grains.
       - Cotyledons left in the soil.
       - Larger grains left in soil—corn, date.
6. Seed distribution.
7. Struggle for existence.

Sequence in Actual Gardening.

Seeds and Flowers.

1. Child receives seeds (5 to 17 kinds, small, large).
2. Plants them (cultural directions, requirements for germination).
3. Energy of seed (growth, force in cracking soil).
4. Kinds of food in different seeds:
   - Oils in peanuts, castor-oil, corn.
   - Proteids in beans, peas, corn.
   - Starch in corn, etc.
   - Sugar in corn, peas.
5. Hypocotyl arch, cotyledons, plumules, roots (embryo).
6. Seed coats above ground and discarded.
7. Seed coats, etc., below ground.
8. Roots (underground). Types of roots.
9. Structure of seed: embryo, food, coats.
10. Seeds always in fruit. Fruit always from flower.
11. Find fruit and seeds in flowers (tulips, lupine blossoms of pea, fruit-blossom).
12. Pollination.
13. Morphology of a flower.
14. Fertilization.

In conclusion, I would just like to point out the difference in the sequence in a course in botany founded directly and entirely upon garden work, such as the one I have described, and the ordinary textbook work. Take the subject of seeds and flowers, for instance, and note the sequence which I have contrasted in outline form. Note that the morphology of the flower, for instance, is placed first in one outline and last in another. Moreover, as I read down the list of topics in the garden sequence, I realize that there was never an instance where this information

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had to be administered in "capsular form." Because of numerous contact experiences through his garden work, the child was always more or less familiar with a topic long before it was handled in class, for the topics were continually bobbing up before them in the garden day after day, in one way or another. In practical individual garden work, it is next to an impossibility to study a subject carefully and thoroughly one day and then to "salt" it and lay it upon the shelf for the test at the end of the month, as we can do so successfully in science courses that do not have the practical work for a basis. I know because I have taught under both systems.

Whether this always is the best way to teach the principles of botany or not in the seventh and eighth grades I am not in a position to say. In my own case, however, I am sure that I have never given a course which has seemed so delightful and so satisfactory. The enthusiasm of the class never lagged. They had a project that they were working for. Their whole aim was, of course, to raise vegetables and flowers, and they were always eager to find out all they could about the science of vegetables and flowers. They were always happy and busy, engaged not only with the mere physical drudgery of working the spade and the hoe, but with deep mental problems concerning their work. This was shown by their conversations with each other and by the hundreds of most intelligent questions that were constantly being asked.

It is not at all the easiest course in the world for a teacher to give, for she must be the spirit back of all of their enthusiasm and back of their observations, and she must often very skillfully be ready to present the opportunity for a little research work, and then so quietly withdraw from the field that the child has the whole pleasure of discovery to himself. Moreover, she must have patience to help the individuals as the occasions arise, which often means explaining the same subject much oftener than by the old class method. However, in spite of all the hard work the teacher is constantly rewarded by the interest and by the intelligence of the pupils, and the pupils, on the other hand, receive their reward when they proudly carry home their onions or their pansies.

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REMARKS ON PSYCHOLOGICAL INVESTIGATIONS BEARING ON THE DISCIPLINARY VALUE OF STUDIES.

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In a preceding paper (pp. 1-10, Jan. 1918), I gave a very brief summary of the experimental work done by psychologists on the transfer of training, leaving the discussion and interpretation of the material to the reader. In what follows, I give a few disjointed fragments of my own theorizing on the question of the disciplinary value of studies, especially of mathematics, and of my reactions to the first-hand literature of the work done by psychologists and to the misunderstanding and misinterpretation of this work in wider nonpsychological circles.

I. One of the chief reasons why mathematics should be studied by all is that it exhibits the best and most convincing type of proof known to the human mind. Mathematical certainty is the most satisfying certainty; the mathematical proof is the ideal of all seekers after truth. Every science consciously endeavors to approximate to the mathematical type as closely as the nature of its materials will permit, and measures the reliability of its results by the closeness of the approximation. Every pupil, girl and boy alike, should be shown this type of proof and given practice in it until he has grasped and assimilated something of its spirit. The pupil will of course gain little unless the ideals of mathematical proof function beyond the confines of mathematics.

The expectation that the ideals will so function is based largely upon myriads of practical experiences like the following by one of the experimenters of our list, experiences that are at least as significant (to put it mildly) as counting dots or crossing off a's. W. C. Bagley[1] "is convinced that students who come into his class in psychology after completing thorough courses in the higher mathematics do far better work than those who have not had this 'training.' Something has been carried over from one study to the other. It is certainly not the *habit* of study, nor are the points that mathematics and psychology have in common sufficient to account for the difference."

But in the present paper, no more overwhelming instance of effective and valuable functioning of mathematical ideals in a large and important nonmathematical field could be adduced than the stately edifice of modern laboratory psychology itself. If one had to differentiate the newer psychology from the old

[1] *Educative Process*, p. 211.

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in a word, it would be hard to do so better than by saying that the new psychology aims to work by exact measurements and to interpret the results in the mathematical spirit.

To read modern psychological literature with ease, and particularly the publications that bear on transfer, one must have a certain degree of familiarity with mathematical terms and methods. One finds plenty of tables, graphs, and curves, and quite a sprinkling of formulas. To a superficial observer the books look quite mathematical, and to a closer reader the dominance of mathematical ideals of proof is evident. See, for example, Thorndike's *Educational Psychology*, or Whipple's *Manual*. Modern psychology itself is a monumental instance of transfer of mathematical ideals and thought-processes.

II. The edifice of experimental psychology has as one of its foundation stones the assumption that the same mental powers function in varying situations, that mental strength can be transferred from one activity to another and more or less different one. This is quite evident when we consider how psychology, following the example of mathematics, endeavors by making situations abstract, simple, and artificial, to control them more completely in the laboratory than can be done in everyday life. But who that does not believe that *the same* mental powers are applied in the more complex situations of real life as in counting dots or crossing off a's would stultify himself by professing to test an individual's mental capacity at any given time, or to measure his mental growth from time to time by his success in counting dots? If anyone finds the situations of mathematics artificial and unrelated to real life, how much more so are those of the psychological laboratory. Truly, the child has outdone its parent! The facts of mathematics have a high content value, but what is the content value of counting dots or memorizing nonsense syllables? Having no content value, what other value can the laboratory tests have than to give information as to how the mind would function in the complex situations of everyday, nonlaboratory life? The very existence of an organized body of such laboratory tests as are described in Whipple's *Manual* voices the belief of its users in the applicability of the powers tested under circumstances that are superficially very different from those of the test.[2]

[2]When I say that the existence of the mental tests currently used implies a belief in transfer, I do not refer to the thirty experiments on transfer enumerated in the list of my previous paper. These were undertaken for the purpose of ascertaining whether or not there is any connection between the particular activities tested, and the experimenter does not by implica-

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III. Not only does the character of the psychological work presuppose belief in transfer, but the frequent use of computation to investigate mental powers that are superficially quite different from computation must needs rest on the belief that the powers applied in these various fields have something of consequence in common with those used in computation. Thus Whipple tells us (p. 461), that the computation test has been employed not merely to study associative processes, but also for the more general purpose of investigating mental efficiency at large. Computation tests have been used to study individual differences in the nature of associative processes; to study the correlation of specific mental functions; to determine the relative influence of heredity and environment upon mental efficiency; to compare the ability of normal, paralytic, and hebephrenic children; to investigate the effect upon mental efficiency of posture, of distraction, of caffein; to investigate the transfer of special drill. "But the commonest application of the computation test has been made in the formulation of the curve of mental efficiency, of the work-curve, with special reference to the influence of practice, rest-pauses, exercise, and similar factors upon the mental efficiency of adults, and especially of children during a school day." In Whipple's *Manual*, the names of the investigators making the tests are given; in all, forty-four names appear, including repetitions.

IV. The term "formal discipline," or "doctrine of formal discipline," is much used by nonpsychologists and occasionally by psychologists, but always by writers who are disclaiming adherence to the doctrine. I have never found the term used and the doctrine defined by a professing adherent of it. Even opponents seldom set up a careful definition of the doctrine, and when a definition is set up it is done with the avowed purpose of knocking the doctrine down, which operation is then immediately performed to the entire satisfaction of the operator.

tion commit himself to any attitude on that matter. But when ability in memorising nonsense syllables is used as a yardstick in educational work, or to help in vocational guidance, then it is obviously assumed that *the same* memory which is applied to nonsense syllables is also applied in other school work and in vocational activities.

The tests to which I do refer are those of the type listed in Whipple's *Manual*. These give a far more adequate picture of the psychology of today than the thirty constituting "all the work on formal discipline." Hundreds of titles are entered in Whipple's bibliographies, and the tests described in his work are of the same general type as those in our list.

The underlying assumption of which I have been speaking is put into words from time to time by psychologists. Thus Whipple (p. 3):

"Outside the laboratory an active and very natural interest in mental tests has been exhibited by those who are busy with practical problems to the solution of which the scientific study of mind may be expected to contribute. It is naturally the educator to whom the development of a significant and reliable system of mental tests would most appeal, since he is concerned with *the development of just those capacities of mind* that the tests propose to measure. . . . Of late, too, hopeful beginnings have been made in application of mental tests to vocational guidance, whether in the selection of people for positions, or the selection of positions for people." (Italics mine.)

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But the reader is driven to ask: "Was there ever anyone who seriously held this prostrate doctrine?"

Thus Heck defines (p. 160): "The doctrine of formal discipline, in its extreme form, implies that the mind is made up or possessed of certain general powers or faculties—memory, imagination, reasoning, etc. These powers are developed by exercise to a degree proportionate to the force and duration of the exercise taken . . . This development . . . of the power involved can be used in response to any other stimulus . . . with little change in nature or diminution in amount. The different powers are considered like different tanks or reservoirs with many pipes emptying into them and many draining out of them. No matter through what pipe water gets into the tank, it can go out by any other pipe and continue almost unchanged through the entire process."

And Bagley (*Educ. Process*, p. 203): "For example; a pupil may acquire the habit of producing neat papers in arithmetic. The doctrine of formal discipline assumes that if this habit is once thoroughly established it will function *equally well* with language and drawing; that functioning successfully here, it *cannot fail* to insure neatness of person and attire; and that the neatness thus ingrained upon the pupil will *surely* be carried over into mature years." (Italics mine.)

Again one is driven to ask: "Who ever held such views?" The few specific citations that I have found of passages supposed to advocate the "doctrine of formal discipline" are far from sufficient to convince me that their writers hold the views just quoted. And some of the attempts to prop up a man of straw to be demolished would be ludicrous if they were not so pathetic. Because, in common parlance, a man may be described as an acute thinker, a shrewd observer, a lover of the beautiful, fond of history, or courageous without always specifying in what subjects he is an acute thinker, of what sort of beautiful things he is a lover, in what phases of life he is courageous, whether in fighting, in facing an audience, or in facing a woman, or of what sort of history he is fond, or in what lines he is a good observer—it by no means follows that all who use these expressions believe that mental power is a sort of entity that can be turned in any direction at will and applied equally well to the solution of any problem, or, that they believe that there is only one sort of courage, or of acute thinking, or of shrewd observing.

V. One investigator has discovered that quickness in arith-

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metic and quickness in marking misspelled words are not necessarily associated. That is, there is no "general" power of quickness. Anyone who has believed in the existence of such a power (though to me the existence of such a believer is mythical) will of course find little comfort in this "discovery." But it is a far cry from this to the assertion that none of the types of quickness which can be trained in the study of arithmetic will function elsewhere.

Some one might conduct a series of experiments to ascertain whether or not quickness in dodging automobiles is necessarily associated with quickness in repartee. One would expect the outcome to be that it is not. And in case the experiment does in fact turn out as common sense would lead one to expect that it will, why should one infer from this result that no training is of any value outside of its own field, that one always learns specific facts and nothing more, and that every subject should be studied for its content merely?

VI. The nonpsychologic reader on this subject must be sure that he understands what is meant if he ever finds a careful psychologist expressing the opinion that this or that specified power cannot be strengthened by training. The meaning may give no support whatever to the view that there is no *gain* from training. The gain may exist but, in the opinion of the psychologist, what produces it may not be technically increased strength of the power in question.

Thus James[3] expressed the view that memory could not be strengthened by training, though he admitted that we could learn by practice how to use more effectively the memory powers with which we are initially endowed. That is, memory is not like a muscle that is strengthened by training, but like a tool that we learn to use better.

One may admit all this, and yet not modify his views as to the desirability of "memory training" or the methods of accomplishing it. Experience has shown that in certain ways we can succeed in *remembering better*. Whether we say that this is done by a strengthened memory or by a better use of an unstrengthened memory is, from the point of view of everyday schoolroom practice and needs, largely a matter of words.

[3] "No amount of culture would seem capable of modifying a man's general retentiveness. This is a physiologic quality given once for all with his organization and which he can never hope to change.

"All improvement of memory consists then in improvement of one's habitual method of recording facts. Native tenacity is not a whit improved. It is a case of better remembering by better thinking. The improvement will, I am sure, be always found to reside in the mode of study and not at all in any enhancement of the brute retentive power." James, Wm., *Principles of Psychology*, Vol. I, pp. 663, 667.

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VII. The experiments thus far made seldom duplicate each other, or even test the same abilities. If any revolution in the world's thought as to transfer is to be warranted by experimental results, the same experiment must be repeated many times with concordant outcomes. Even simple physical experiments, whose results are foreknown with quasi-mathematical certainty, are repeated hundreds of times in our physical laboratories. A thing has not been proved experimentally unless the experiment has been frequently repeated with uniformly the same result. Consider, for example, the experiment which examines the falling of a bullet and a feather in a vacuum, and which exhibits the two objects falling one about as fast as the other in an approximate vacuum. If this were a laborious and complicated experiment, and if it had been done only once in all the world; if in that one trial there had been many possibilities of vitiating influences; would or should any physicist reverse or even modify his views of the law of gravitation in consequence of this experiment alone? Even if the results of this one experiment were to point definitely in the direction of a modification of his views (and we have seen that the trend of the experimental results on transfer is affirmative and not negative), would he not demand that first of all the experiment be repeated over and over until all irrelevant and disturbing factors had been eliminated and the essential outcome and meaning of the experiment fixed beyond peradventure?

VIII. The experiments usually show about that measure of transfer which it seems to me common sense and experience would lead one to expect. A few show less, and a few show more. Thus, I should not have expected (Experiment VII) that practice on memorizing the order of four tones would cause improvement in the memory for poetry or for the order of four shades of gray. But psychologists are not yet in a position to give expert verdicts or anywhere near it. Psychologists of high rank are the first to recognize this, and to deprecate the impression that has gained currency among the less well-informed to the effect that psychology has *settled* the general problems in this field. Thus Whipple (pp. 3-4):

" . . . there has been, unfortunately it seems to us, a disposition in some quarters to speak as if a science of mental tests were already achieved; . . . To make such assertions is surely misleading, for . . . there is at the present time scarcely a single mental test that can be applied unequivocally as a psychical

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measuring rod. The fact is we have not agreed upon methods of procedure; we too often do not know what we are measuring; and we too seldom realize the astounding complexity, variety, and delicacy of form of our psychical nature."

IX. Coover in an extensive recent study* gives a general survey of the field, a detailed account of his own experiments and an extensive bibliography. In summing up, he says (pp. 234, 241):

"Evidence from the literature of experimental psychology indicates a functional relationship between various mental processes. . . . Under experimental conditions the 'general' effect usually ranges, in amount, from one-fourth to three-fourths of the gain made in specific practice. . . . The contribution (of experimental research in the psychological laboratory) is important in that it shows the general effect of special practice; but it is limited in its scope to fairly simple processes, to periods of short training, and, for introspection, to reagents upon whom training does not produce great practice effect. Were the processes as complex and various as those engaged in the study of Greek, mathematics or science; were the training extended over four school years instead of ten weeks under limiting laboratory conditions; and were the subjects in the plastic period of the 'teens,' it is conceivable that the extent to which the training is general would be found to be greatly in excess of the laboratory figures."

Few of the experiments of the list in my previous paper studied the effect on a large number of persons, of work in a given branch of study for a considerable length of time under ordinary classroom conditions. This is, of course, what the educator needs chiefly to know. In this respect, the experiment of Rugg (XXX) is by far the most satisfactory of the list and indicates a line along which further experiment is desirable. It is difficult to conceive of a broad educational thesis as conclusively *proved* experimentally until it has been repeatedly verified under classroom conditions.

X. My conclusion as to the whole matter is that in the psychological experiments we have a body of minute work spread very thinly over portions of an enormous field; that the work is markedly heterogeneous as to method, thoroughness, and standards of scientific accuracy; that even within the range of the experiment itself the results are often by no means conclusive,

*Coover, J. E., Formal Discipline from the standpoint of Educational Psychology, Psychological Monographs, No. 87. Princeton, N. J., 1916, pp. viii+307.

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and that the sum total is as yet far from constituting a scientific proof of any general thesis.

Let me illustrate by a specific example.

In Foster's experiment (No. XVIII), three adults (two doctors of philosophy, one university instructor of psychology), all evidently fully matured men with well-established mental habits, practiced forty hours in reproducing groups of dots, irregular polygons, nonsense and sense drawings and objects. They believe, on the basis of introspection, that their "power of visualizing" was not strengthened. Was it even trained? They were allowed to follow lines of least resistance. After the practice, they were able to do that type of task better. No test is reported aiming to ascertain whether or not they could do analogous tasks better; there was no untrained "control group" with which to compare the practiced group. We have only the opinion of the experimenters (introspectively attained) that this practice did not make them "noticeably better observers or memorizers in general, or give them any habits of observing closely or reporting correctly, or furnish any ability to meet better any situation generally met with" (p. 21).

Who expected that it would? Who has ever expected that copying dots would equip one to deal better with "situations generally met with," such, let us say, as running an automobile, writing a business letter, or deciding how to vote on the tariff?

And on the question of whether or not young children, with unformed and rapidly developing habits of visualization, should be taught drawing in school, the experiment seems to have nothing to say. Still less does it warrant teachers of Latin, physics, or mathematics in passing along the awe-struck whisper: "Psychology has pronounced the verdict! Our subjects give no valuable training. What value they have lies exclusively in their content."

The psychological researches that have been made are valuable but they are as yet mere scratches on the surface of a field that needs to be mined deep. Mental acts at their simplest are complex. Good psychologists would be the first to tell us how little has as yet been done in the direction of reaching an ultimate analysis of these complexes, or in the direction of determining to what extent the psychic powers at work in different mental acts are the same.

Meanwhile, the work of education must go on as best it can on the basis of common sense and the accumulated results of

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daily experiments in the classroom laboratory by the teachers of today and their predecessors throughout the ages. Accurate results of research in all fields will be welcomed by the progressive teacher, and their definite indications followed out, but he will ask that the results and indications *be* accurate and definite. As far as possible he will get his information at first hand, that is, from the publications of the original experimenters. In so far as he cannot do this, he will ask at least that those who bring him the information should have themselves obtained it at first hand, and that they give specific reference to the original sources, and that they make clear distinction between the results which they report and their own interpretation of these results.

To one who will not conform to this reasonable requirement, but who offers merely vague, sweeping, unsubstantiated generalities, the wide-awake teacher will pay no heed, but will go on in the even tenor of his way, doing his utmost along the lines that have given the best account of themselves under the practical classroom tests of the past. He will strive to keep an open and progressive mind, realizing that the surest and sanest progress will be made by careful and gradual modification of the existent structure, and he will not be carried away by the rhetoric of those who wish to tear down the edifice that now houses us educationally (at least tolerably, even though far from perfectly), before a new and better edifice has been built for us to occupy.

If anyone would ask us to change our beliefs or our practices, it is obviously his duty to present and prove reasons why the change should be made. This every good psychologist is willing to do, and nothing is more characteristic of the writings of psychologists, seen at first hand, or their expressions of views face to face, than their evident aim to state all the facts fairly and clearly, and to claim as proved no more than the results of investigation will warrant. The results reached by psychologists working in the scientific spirit, when received and interpreted in the same spirit, can do only good. But danger lies in the accretions and distortions that the descriptions of these results undergo when handed down the line from science to rhetoric, from first to tenth hand.

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SANITARY SURVEYS CONDUCTED BY STUDENTS.

By F. E. Chidester,

Rutgers College, New Brunswick, N. J.

In connection with the study of hygiene and sanitation in schools and colleges, it is most desirable that the student be given practical experience in the field. It is possible by interesting the young people of a community in actual conditions to so awaken the adult that some good may result. A survey may consist either in a general study or in a specific study which includes house-to-house inspection. An outline which has been found valuable in making surveys of smaller cities not completely provided with sewerage systems follows:

Location and Population.

First of all one must learn of the provision for natural drainage. It is important to learn not only the elevation of the town and its relation to streams, but also to know the character of the soil and the rapidity and direction of the seepage. A study of the population will indicate almost immediately the living customs which predominate.

Buildings.

In addition to a study of the houses and outhouses, it is of utmost importance to learn the distribution of barns and stables, which are so important in the production of the typhoid fly and other injurious insects. A study of the factories will often disclose almost unbelievable insanitary conditions. The production of wastes from certain manufactories and the ultimate disposal of such wastes is also extremely important. In smaller cities where complete sewerage systems do not exist, the disposition of outhouses is of the utmost importance. In the majority of the smaller cities it is usually found extremely difficult to enforce the law regarding depth of pits and the relative positions of the outhouse and the well. In some of the foreign districts of a city one may find a community well into which drain numerous cesspools.

Streets.

The condition of the streets and the establishment or enforcement of ordinances regarding care is often of the greatest importance even in comparatively small municipalities. Sprinkling or oiling streets is often feasible in small towns not able to engage in paving.

Sewerage.

In cities which have well-constructed sewerage systems, one

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often finds the outlets to be in a stream so near another municipality as to seriously jeopardize the health of the receivers of the waste.

Supplies.

Water.

Municipal water supplies are often much more carefully examined and regulated than are the numerous wells and cisterns which are privately owned. Another source of disease is the improperly regulated spring water distributor.

Ice.

Ice may be beautiful in clearness and yet may be taken from pools which contain animal waste. Drivers of ice wagons are known who invariably wash the ice with water from a city horse trough. The danger of anthrax and actinomycosis is well known, while from the aesthetic point of view much is to be desired. Artificial ice is without question far superior, but even here the possibility of disease transmission is considerable.

Milk.

Milk, as is well known, may be of the very highest quality, and yet contamination by one or more typhoid carriers may produce serious epidemics. Nonenforcement of the law regarding sterilization of bottles is also likely to exist.

Bread.

Among the greatest offenders against the health of the consumer are the bakers. In many cases bakeries are situated in basement rooms, and the bread is exposed to flies and other disease-bearing insects. Even today one finds cases of unwrapped bread packed in a dirty wagon and exposed to street dust.

Vegetables and Fruits.

Vegetables which are grown by people of certain nationalities are fertilized with human feces, and if insufficiently washed before coming to the table may be a cause of disease transmission. Likewise, fruits, such as bananas, ripened in the cellars or sleeping rooms of the dealers, may carry large numbers of disease germs. The exposure of fruits and vegetables uncovered may also result in acquirement of considerable disease-bearing street dust.

Meats.

In the large cities where all meats come from slaughter-houses inspected by Government veterinarians, one need suffer little apprehension regarding the health of the animal. It is in the

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smaller cities and in the villages where unregulated slaughter houses exist that one finds diseased animals most numerous. The after care of meats while hanging in the storehouses or in butcher shops also demands considerable attention. In too many cases does one find that meats are exposed to flies for several hours of each day.

Candy.

Candy factories run on a small scale are often extremely dirty. Closer supervision of manufacture must exist before the introduction of injurious ingredients in cheap candies can be eliminated.

Soda Fountains.

Some of the most flagrant violations of the law and of common decency exist in soda fountains situated in apparently respectable drug stores and lunch rooms. In comparatively few cases does one find that the glassware is sterilized after use. In the majority of cases one sees rinsing in dirty cold water to be the only means of cleaning.

CARAVANSARIES.

Students have no difficulty in obtaining admittance to the kitchens of hotels and restaurants. In fact the proprietors are afraid to forbid them entrance. Without question the fear of inspection itself is sufficient to cause general clean-ups.

JAIL.

It goes without saying that even high school students should visit courtrooms and learn the procedure. It is also of considerable importance that the community should know the conditions under which prisoners live in the jails. In too many cases the jails are horribly insanitary and are managed in the most medieval fashion.

AMUSEMENT PLACES.

It is doubtful whether young men should be encouraged in making an inspection of saloons. They should, however, become familiar with the scientific literature, and they could profitably spend some time in studying the effects of alcoholism in their own town.

Theatres and moving picture theatres need the most careful and critical inspection. If the opinions of even immature children were gathered by the theatre managers, many shows would be discontinued. After all, the vulgar is not enjoyed by the majority of young people.

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Churches and Schools.

It is unfortunate that the supposedly model places, the schools and churches, are often among the most unhygienic buildings in the town. It needs but little scrutiny to see many points in which these might be improved. With youth enlisted in the cause, it would be but a short time before conditions would be remedied.

Hospitals.

The fear of the hospital which even today exists in the minds of many, would tend to be eliminated if all young people were taken on tours of inspection of the work and benefits of a well-organized hospital.

Cemeteries.

With young people instructed in sanitary methods, the insanitary cemetery will probably be replaced by the crematory. At any rate, wells near cemeteries would not be used in the smaller cities.

Vital Statistics.

A proper realization of the death rates and the relative susceptibility to certain diseases at different ages is of inestimable value in inducing young people to take proper precaution and insist on the enforcement of the health laws of their town.

Sanitary surveys have been made by the writer's classes in a city of 30,000 inhabitants and in a village of 5,000.

While the prospective teacher may benefit by a brief preliminary training in methods of conducting such a survey, the greatest benefit results from the awakening of children and parents to existing evil conditions which menace their lives.

A SMALL TABLE OF VALUES OF THE BINOMIAL COEFFICIENT.

By C. H. Forsyth,

Dartmouth College, Hanover, N. H.

Binomial coefficients play such an important part in so many branches of mathematics, such as binomial expansions, combinations, finite differences, etc., that it seemed worth while to offer a small table of values of the coefficient for reference, together with an explanation of a single method of setting them up, based solely upon continued or cumulative addition.

Although the table is small—a larger table would necessitate too much space—it will probably meet the vast majority of

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everyday needs, while the suggested method of constructing the table will enable anyone to lengthen the table easily and quickly to meet particular needs.

As is well known, the expansion of $(a+x)^n$ may be written:

$$(a+x)^n = a^n + {}_nc_1 a^{n-1}x + {}_nc_2 a^{n-2}x^2 + \cdots + {}_nc_r a^{n-r}x^r + \cdots$$

where ${}_nc_r$ means the number of different combinations of n things taken r at a time. The table gives values of ${}_nc_r$ for all values of n up to 20.

In order to simplify the construction of such a table, and finally to provide a check upon the work, two simple formulas are needed:

$$\text{Since } {}_nc_r = \frac{n(n-1)(n-2)\cdots(n-r+1)}{r!}$$

$$\begin{aligned} {}_nc_r + {}_nc_{r+1} &= \frac{n(n-1)(n-2)\cdots(n-r+1)}{r!} \\ &\quad + \frac{n(n-1)(n-2)\cdots(n-r)}{(r+1)!} \\ &= \frac{(n+1)n(n-1)\cdots(n-r+1)}{(r+1)!} \\ &= {}_{n+1}c_{r+1} \end{aligned} \tag{1}$$

which means that if the values of ${}_nc_r$ are laid out in rows by r's (as in the table), the sum of any two adjacent values gives the value just below the second. A glance at the table will render this fact clear and show that it may be applied to construct as large a table as is desired solely by continued or cumulative addition.

Since ${}_nc_r = {}_{r+1}c_{r+1} = 1$

by (1) ${}_{r+1}c_r + {}_rc_r (= {}_{r+1}c_{r+1}) = {}_{r+2}c_{r+1}$

Again, by (1)

${}_{r+2}c_r + {}_{r+2}c_{r+1} (= {}_rc_r + {}_{r+1}c_r) = {}_{r+3}c_{r+1}$

Continuing in this way, we have finally

$${}_rc_r + {}_{r+1}c_r + {}_{r+2}c_r + \cdots + {}_nc_r = {}_{n+1}c_{r+1} \tag{2}$$

which means that the sum of the values, *except the last one, in* any column gives the last value in the next column to the right. Thus (2) can be used as a check upon the preceding work.

To those familiar with the finite calculus the following deriva-

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tions of formulas (1) and (2) should prove interesting and seem more direct:

as ${}_nC_r$ may be written $n^{(r)}/r!$ where $n^{(r)} = n(n-1)(n-2)\cdots(n-r+1)$

then, with n as the variable

$$\Delta {}_nC_{r+1} = {}_{n+1}C_{r+1} - {}_nC_{r+1} = \Delta\frac{n^{(r+1)}}{(r+1)!} = (r+1)\frac{n^{(r)}}{(r+1)!} = \frac{n^{(r)}}{r!} = {}_nC_r$$

which is formula (1).

Therefore, $\sum {}_nC_r = {}_nC_{r+1} + \text{constant of integration}$

and $\sum_{n=r}^{n=n} {}_nC_r = {}_{n+1}C_{r+1} - {}_rC_{r+1}(=0) = {}_{n+1}C_{r+1}$

which is formula (2)

When r exceeds 9, the table should be entered with $r = n-r$, remembering that ${}_nC_r = {}_nC_{n-r}$

${}_nC_r$

n	r=1 or n−1	r=2 or n−2	3 or n−3	4 or n−4	5 or n−5	6 or n−6	7 or n−7	8 or n−8	9 or n−9
1	1								
2	2	1							
3	3	3	1						
4	4	6	4	1					
5	5	10	10	5	1				
6	6	15	20	15	6	1			
7	7	21	35	35	21	7	1		
8	8	28	56	70	56	28	8	1	
9	9	36	84	126	126	84	36	9	1
10	10	45	120	210	252	210	120	45	10
11	11	55	165	330	462	462	330	165	55
12	12	66	220	495	792	924	792	495	220
13	13	78	286	715	1287	1716	1716	1287	715
14	14	91	364	1001	2002	3003	3432	3003	2002
15	15	105	455	1365	3003	5005	6435	6435	5005
16	16	120	560	1820	4368	8008	11440	12870	11440
17	17	136	680	2380	6188	12376	19448	24310	24310
18	18	153	816	3060	8568	18564	31824	43758	48620
19	19	171	969	3876	11628	27132	50388	75582	92378
20	20	190	1140	4845	15504	38760	77520	125970	167960

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RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.

University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

TUNGSTEN, TANTALUM, COLUMBIUM.

By GEORGE W. SEARS,

Assistant Professor of Chemistry, University of Nevada.

The chief characteristics in the history of many of the rarer metals may be summed up in the three phrases, a chemical curiosity, investigation from a purely scientific standpoint, the discovery of useful and valuable properties followed by a rapid development. Tungsten, tantalum, and columbium give us a picture, as it were, of this history. Less than twenty years ago tungsten was practically unknown, but a careful study of its properties soon led to its employment in the steel industry and later in the manufacture of filaments for incandescent electric lamps, so that now it is almost a household word. Tantalum is just coming into prominence as a useful metal, and tantalum dental and surgical instruments are eagerly sought by those who have learned their value. Columbium is yet but little more than a chemical curiosity with practically no commercial application.

Situated as they are in the fifth and sixth groups of the periodic table, these three elements show a relation in their physical properties and chemical activity which might well lead one to expect that both tantalum and columbium will attain the wide range of usefulness which already has been reached by the more fully developed tungsten. In appearance, specific gravity, and melting point they are not widely different. Pure tungsten and tantalum are characterized by their ductility, toughness, and malleability, while in the less pure condition both are extremely hard and brittle. In columbium these properties are somewhat less marked. In the cold all three are very inert but rapidly oxidize on heating to redness. With the exception of hydrofluoric acid tantalum and columbium are unattacked by all acids or mixtures of acids. Tungsten is slowly dissolved in hot concentrated sulphuric or hydrochloric acid. All are stable toward solutions of caustic alkali but are attacked by molten alkali nitrates, sulphur, and fused caustic alkali.

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The chief ores of tungsten are wolframite, scheelite, hubnerite, and ferberite. Although ores containing tungsten have been known for a long time it was not until 1781 that Scheele discovered in scheelite a peculiar acid which he named tungstic acid. A little later the same acid was shown to exist in wolframite. While tungsten ores occur in a number of localities in both Europe and America, the United States is by far the largest producer. In 1916 the output in the United States amounted to 3,200 tons valued at $9,400,000. Large deposits of ferberite and scheelite are found in Boulder County, Colorado, from which a large part of the United States production has been taken. Considerable amounts of hubnerite, wolframite, and scheelite are being mined in Nevada and California.

Owing to the high specific gravity of tungsten ores, their concentration by various mechanical settling processes is relatively simple. However, certain European ores contain large amounts of cassiterite from which it is very difficult to separate the tungsten by these processes. It has been found advantageous in these cases to make use of magnetic separators. The tungsten ore usually contains enough iron to give it magnetic properties. The further treatment of the concentrate varies somewhat with the nature of the ore. A method which has been used quite extensively with wolframite consists in fusing the concentrated ore in a reverberatory furnace with a mixture of Na_2CO_3 and $NaNO_3$. This produces a soluble sodium tungstate which is lixiviated with water, filtered from insoluble matter and the tungstic acid precipitated with hydrochloric acid. The method has not been wholly satisfactory owing to the large quantities of reagents necessary and the consequent loss due to the slight solubility of the precipitates. Scheelite may be decomposed with concentrated hydrochloric or nitric acids with the formation of a soluble calcium salt and insoluble tungstic acid.

For the production of pure tungsten, ammonium tungstate is precipitated from a solution of alkali tungstate with a current of ammonia gas. This is purified by further recrystallization and finally precipitated as WO_3 with nitric acid. The oxide obtained in this manner is dried, ignited, and reduced in a current of hydrogen at a temperature of 1000° to 1200°. A pure tungsten cannot be obtained by reduction with carbon, owing to the formation of tungsten carbide (W_2C).

By far the largest part of tungsten produced is used in the

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manufacture of steel. This finds a ready market for high speed tools, armor plate, projectiles, and firearms. Perhaps the most important property which it imparts to steel is extreme hardness and toughness. It is added in proportions varying from 2 to 12 per cent of the steel. Either alone or as an alloy with molybdenum it is finding increasing use as a substitute for platinum in the manufacture of contact points for electric welding, spark coils, signal relays, sending keys, etc. Owing to its greater conductivity and higher melting point it remains much cooler during operation and lasts longer than the platinum. Alloyed with thorium it is used as a refractory material.

Compounds of tungsten also find considerable use. Sodium tungstate is used in fireproofing curtains and draperies. Calcium tungstate on account of its fluorescence is used as a screen to make X-rays visible. Other compounds are used in glass and porcelain coloring, in making certain bronze powders, and in weighting silks. The amount of tungsten used for these purposes, however, is still relatively very small. The total consumption of tungsten in 1915 for purposes other than steel was about five tons, or less than 1 per cent of the tungsten produced.

Tantalum and columbium occur in a large number of ores and almost invariably occur together. Only a very few of these ores, however, are as yet of commercial importance. Tantalite containing from 40 to 70 per cent Ta_2O_5 is the chief source of tantalum. In most specimens of tantalite[1] some of the iron is replaced by manganese and some of the tantalum by columbium. Columbite is similar to tantalite in composition except that it contains a larger proportion of columbium. Although small amounts of tantalite are mined in Connecticut and in the Black Hills, the large majority of the tantalum so far used is obtained from Western Australia, where a high grade tantalite is found. As a rule the Australian tantalite contains 50 to 70 per cent Ta_2O_5 while that found in America seldom has more than 40 per cent.

Owing to the great similarity in the chemical nature of tantalum and columbium and the insolubility of their salts in the common acids, their separation and reduction are comparatively difficult and tedious operations. The metallurgy consists of two distinct procedures, first the preparation of a pure salt, and second its reduction to the metal. According to the method of Marignac (1866), the finely powdered ore is fused

[1]The general formula of tantalite is given in the table at the end.

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with three times its weight of $KHSO_4$. The fused mass is cooled and lixiviated with water. Tantalum and columbium along with small amounts of tin, tungsten, iron, and silica are left undissolved. This residue is digested with $(NH_4)_2S$ to remove tin and tungsten, then treated with hydrochloric acid to dissolve the iron. After a thorough washing the remaining tantalum, columbium, and silica are dissolved in hydrofluoric acid. By this treatment the silica is volatilized as SiF_4. To the solution containing only tantalum and columbium fluorides KF or KHF_2 is added when most of the tantalum precipitates as K_2TaF_7 and most of the columbium is left in solution as K_2CbOF_5.

A more satisfactory method, however, than that of Marignac consists in fusing the ore with potassium hydroxide. This renders the tantalum and columbium soluble in water while most of the impurities remain in the residue. The solution containing the tantalate and columbate of potassium is acidified with hydrofluoric acid which precipitates most of the tantalum as in the method of Marignac.

Tantalite and columbite may be decomposed directly with hydrofluoric acid and the K_2TaF_7 precipitated from the resulting solution by the addition of KF or KHF_2. This method, however, is not very satisfactory since iron and manganese form double fluorides isomorphous with K_2TaF_7, thus rendering their separation much more difficult.

The K_2TaF_7 obtained by any of the above methods is further purified by recrystallization from water made slightly acid with hydrofluoric acid. In order to obtain the salt in the purest condition three to four crystallizations have been found necessary.

The reduction to metallic tantalum may be accomplished in a number of different ways. One of the oldest methods, proposed by Berzelius and Rose, consists in placing the K_2TaF_7 in a crucible with layers of metallic sodium and starting the reaction by the application of heat. When the reaction is complete and the mass is cool it is treated first with water and then with nitric acid. The metallic tantalum is left in a more or less impure condition.

In 1903 von Bolton patented an electrolytic process in which the fused K_2TaF_7 is electrolyzed, giving a somewhat impure metallic powder. This is further purified by melting in vacuo between tantalum electrodes. By this means the impurities which are more volatile than tantalum are vaporized. The

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Thompson-Houston Co. of England obtained a patent in 1906 whereby they electrolyze the fused K_2TaF_7 in a refractory crucible of magnesia or tantalic oxide, using a cathode of pure tantalum and an anode of impure tantalum. In 1907 a French patent was obtained which provided for the electrolysis of a solution prepared as follows: A solution of potassium tantalate is precipitated with sulphuric acid, filtered, washed with water, and redissolved in oxalic acid.. The solution obtained in this way is neutralized with ammonia, and sulphuric acid is added to make a three per cent solution. This is electrolyzed between platinum or carbon electrodes, using 2 volts and .1 to .3 amperes. This process is said to give very pure tantalum.

Carbon cannot be used for the reduction of tantalum compounds, owing to the formation of tantalum carbide.

It has already been mentioned that tantalum is only in the beginning of its usefulness. Its employment in the manufacture of electric light filaments was just coming into prominence when the advent of the more efficient tungsten filaments drove it completely off the market. The comparative efficiency of the various filaments is shown in the following table:

Kind of Filament.	*Watts Required per Candle Power.*
Carbon	3.00
Metallized carbon	2.50
Tantalum	1.70
Squirted tungsten	1.25
Drawn tungsten	1.00
Nitrogen filled tungsten	.50

The dental and surgical instruments made of tantalum possess many advantages in that they are nonrusting and may be sterilized in acids or at a moderate red heat. They can be sharpened the same as steel. For dental purposes the instruments are surface hardened by secret processes so that they are about as hard as agate. Tantalum pens, employed quite extensively in Germany, possess great elasticity and hardness, do not rust, and are not corroded by the ink. Tantalum may be used to replace platinum as cathode in all places. When used as anode, however, it becomes coated with a poorly conducting oxide, Ta_2O_4. Many metals as silver, copper, zinc, nickel, platinum, and antimony have been quantitatively deposited on tantalum cathodes. Tantalum cathodes possess the added value that the deposited metal may be dissolved off with acids or even aqua regia. It has been suggested that tantalum weights would be equally good if not superior to those of platinum. Laboratory fumes

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would have no corroding effect. Tantalum has found only a limited use in the manufacture of steel.

From a commercial standpoint the compounds of tantalum are of little importance except as a means of its separation and purification. The oxide, Ta_2O_5, has a limited use as a refractory material. It has already been said that K_2TaF_7 is the compound usually prepared for the separation and purification of tantalum, it is therefore the starting point for the preparation of other compounds of tantalum.

Up to the present time the chief interest in columbium has been that of the purely scientific investigator. The fact, however, that a U. S. patent taken out only last year (1916), providing for .1 to 10 per cent of columbium to be mixed with tungsten for making incandescent electric light filaments, is an indication that useful properties are being discovered and that uses will be found.

For the separation of columbium and its purification the K_2CbOF_5 solution obtained in the precipitation of tantalum as K_2TaF_7 is evaporated to dryness and ignited at a low temperature for several hours to render the tantalum insoluble. This ignited residue is moistened with strong hydrofluoric acid, then taken up in water and the whole process repeated until no further test for tantalum is obtained. The pure columbium salt is decomposed by heating strongly with sulphuric acid, cooled, and the resulting columbic acid washed with large volumes of water to free it from K_2SO_4. On ignition Cb_2O_5 is obtained. If this is mixed with paraffin and drawn into fibers it may be reduced to Cb_2O_4 with carbon. The tetroxide formed in this way is a conductor and may be reduced to metal by heating highly in vacuo. The metal may be obtained also from the pentoxide by means of Goldschmidt's process or by reduction with "mischmetal." By passing $CbCl_5$ vapors mixed with hydrogen through a red-hot tube the columbium is reduced. It may be obtained by the electrolysis of K_2CbOF_5, using methods similar to those for the preparation of tantalum.

The compounds of columbium are in general similar to those of tantalum and possess very much the same properties. A few differences, however, may be noted. K_2TaF_7 crystallizes in long needles belonging to the orthorhombic system and is soluble in 150 parts of water, while the corresponding columbium compound, K_2CbOF_5, crystallizes in hexagonal plates and dissolves in 12 to 13 parts of water. Advantage is taken of this differ-

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ence in the separation and detection of the two elements. The shape of the crystals is the most delicate and reliable test for either tantalum or columbium. Freshly precipitated columbic acid when treated with zinc and hydrochloric or sulphuric acid forms reduction compounds with hydrogen peroxide, potassium thiocyanate, potassium ferrocyanide, tannin, and pyrogallic acid as well as with a number of other compounds. In each case the resulting compound is colored. Tantalic acid is not reduced under similar conditions.

The following table gives a comparative view of the three elements.

Element.	Tungsten.	Tantalum.	Columbium.
Principal ores	Wolframite ($(Fe, Mn)WO_4$) Scheelite ($CaWO_4$) Hubnerite ($MnWO_4$) Ferberite ($FeWO_4$)	Tantalite ($FeTa_2O_6$) Microlite ($Ca_2Ta_2O_7$) Fergusonite ($(Y, Er, Ce)(Ta, Cb)_2O_4$)	Columbite ($(Fe, Mn)(Cb, Ta)_2O_4$) Samarskite III II $R_2R_3(Co, Ta)_6O_{21}$
Color	Gray to brownish black	Dark gray	Steel gray, brilliant luster
Hardness	Cast metal very hard, pure metal much softer	Equal to ordinary steel	Equal to wrought iron
Specific gravity	18.8	16.8	12.7
Melting point	3080°C.	2910°C.	1950°C.
Effect of heat	Burns slowly to oxide. Powder burns very readily.	Burns slowly to oxide. Powder burns very readily.	Burns slowly to oxide. Powder burns very readily
Action toward acids	Attacked by hot HCl, H_2SO_4, or mixture of HNO_3 and H_2F_2	Attacked by H_2F_2 only.	Attacked by H_2F_2 only.
Action toward alkalies	Attacked by fused alkalies, alkali nitrates, carbonates, and disulphates.	Attacked by fused alkalies and alkali nitrates.	Attacked by fused alkalies and alkali nitrates.

THE BONDS ON STOCK EXCHANGE.

The daily quotations of Liberty Loan bonds on the New York Stock Exchange below par do not represent any real loss for those holders of Liberty Loan bonds who do not need to sell them. The figures do mean a very small loss for those who find themselves compelled for one reason or another to sell; but those who hold on to their bonds have one of the very best investments in the world—absolutely safe, free to a great extent from taxation, and bringing in an absolutely certain income. The loss to them is purely imaginary, a paper loss, not a real one.

Secretary McAdoo, in a speech before the Liberty Loan conference in Washington, December 10, made the statement that, while sufficient legally competent evidence was not in hand to warrant conviction before a jury, yet enough was known morally to convince a man of understanding that the hand of the Kaiser was at work in bringing about sales of Liberty Loan bonds and depressing their price on the exchange. This is added proof that the loss indicated by the difference between par and the stock exchange prices is fictitious and not real.

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RESEARCH IN BIOLOGY.

Conducted by Homer C. Simpson.
Ohio State University, Columbus.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to Dr. Homer C. Simpson, Department of Zoology, Ohio State University, Columbus, Ohio.

A REVIEW OF SOME RECENT ATTEMPTS TO INFLUENCE THE GERM PLASMS OF ANIMALS.

By W. M. Barrows.
State University of Ohio, Columbus.

The value of zoology aside from its practical applications in animal breeding, in the elimination of pests, et cetera, extends much deeper and has a more definite philosophical significance than we are accustomed to recognize. Many of the practical problems of everyday life are settled by what we know, or think we know, about the activities of our own bodies or about those of familiar animals. Our whole view-point in life is very largely determined by what we know about the factors which are to improve or damage the generations which are to follow us. The high school student who is told that men are the products of their environment will have an entirely different outlook from one who is told that "blood will tell" and that the environment has little effect on what a man is or what his descendants will be. Let us cite two specific cases. We have been taught that a drunkard is the result of his environment alone or the environment of his ancestors, that alcoholism causes the development of alcoholics. Very few teachers have the courage to point out that a weak nervous system which is inherited may lead to alcoholism and that the son may be like the father (alcoholic), not because of the environment but because of the inherited lack of something in his nervous make-up which allows him or even leads him to become a drunkard or to go to other excesses. Again, the whole question of blind fish in caves may be stated in two ways—first, are fish in caves blind because of the action of the darkness of the caves on their germ plasms or on each embryo as it develops, or, second, are they in the caves because in going blind regardless of the light they could survive only in such places as caves, where competition is less severe and eyes so necessary?

It is not the intention to take these matters up here. They

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have been discussed from several points of view by Eigenmann, Davenport, Jennings, Conklin, and others. References to these articles may be found in the bibliography at the end of this article. Obviously, any experimental work which demonstrates the effects or lack of effects of the environment on the germ plasm of animals will have a direct bearing on this subject. It is with this idea in mind that the following material is reviewed.

It is quite obvious that the developing chick in the egg is not much influenced by the activities of the mother hen except as regards temperature, moisture, and mechanical disturbances of the egg. In other words, a good incubator will hatch out the same kind of chicks and will hatch them about as well as their own mother. We must not forget, however, that the egg cells (yolks) as they develop in the ovary may be influenced by the body of the female parent before they are laid or the sperm cells in the male may be influenced. Among the mammals, the developing young are separated from the female parent but not so completely as are the chicks in the egg. Three questions arise in our mind immediately. Are the eggs and developing young more influenced by the parent or less than those of the bird? Do external factors influence the germ cells before fertilization? If so, do the same stimuli affect different animals in different ways? While recent researches have not given by any means a complete answer to these questions, some progress has been made and many interesting experiments have been recorded.

In 1897 Heape showed that when the fertilized egg of a rabbit of one variety (for example, a long-haired albino) was removed from the oviduct of the mother before it had become attached to the uterine wall, and was transferred to the oviduct of a rabbit of a different variety (for example, a Belgian hare which is neither white nor long-haired), the transferred egg became attached in its new position and passed through all the stages of gestation. Young rabbits produced in this way were both long-haired and albinos like the mother of the eggs, not like the rabbit which bore the young (Castle and Phillips). This experiment shows very clearly that the body of the parent has little if any effect on the developing young. It does not indicate, however, that the eggs may not be influenced by a foster mother if they *grow up* and mature in the body of the foster mother. This case may be tested by transplanting the ovary from one individual to another and allowing the egg to go through the stages of

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development previous to fertilization within the foster mother.

Castle and Phillips have made many ovary transplantations from one young female guinea pig to another. These foster mothers were then mated to males whose color and ancestry were known. In three cases the foster mothers raised young. In one case an ovary from a black female had been placed in a white guinea pig which was then mated to a white male. White offspring would be expected because white by white always produces white. However, the six young were all black. The eggs from the black female had not been influenced so far as could be detected. These and other experiments make it seem unlikely that the body cells or normal bodily processes leave any effects on the germ cells.

Eggs developing in the ovary or sperm cells developing in the testis if not influenced by the parents' make-up are not likely to be influenced by the ordinary changes in the environment from which they are protected by the body of the parent. Some changes of the environment, however, do penetrate the tissues of the ovary or testis and may cause changes directly in the germ cells.

Two interesting series of experiments in which alcohol vapor was administered to fowls and guinea pigs did not yield exactly similar results. According to Stockard, offspring from guinea pigs, which had been made to inhale alcohol for long periods before mating, were much less vigorous and showed among them many more abnormal young than the untreated stock. These abnormal young appeared during the three or four generations subsequent to the treatment, the individuals showing abnormal nervous systems, sense organs (especially the eyes), and in a few cases abnormal legs. Analysis of his results indicates that sperm cells are more easily affected by alcohol than egg cells, and it seems likely also that the sons of alcoholized mothers are more affected than the daughters, while the daughters of alcoholized fathers are more injured than the sons. The per cent of deformed offspring from inbred descendants of alcoholized stock sometimes ran as high as fifteen per cent, while the descendants of normal stock showed no deformities.

If we assume that alcohol has the same effect on man and guinea pigs we would have data to delight the most ardent prohibitionist, but before making the comparison it may be well to note two more researches. In a long and carefully executed experiment with fowls which were made to inhale

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alcohol, methyl alcohol, or ether, Pearl has found that from birds, one or both of which had been treated, fewer fertile eggs were obtained, but of these eggs which were fertile fewer died during development than in the untreated stock. The offspring of treated parents showed a higher average body weight than the offspring of the untreated. They were a selected, superior set of offspring, the weaker eggs and sperms having been eliminated by the treatment. The treated and untreated animals produced about the same proportion of abnormal chicks (treated, 1 to 234, untreated 16 to 1,527). This indicates that surviving eggs and sperms were not injured so far as could be detected, though it is possible that a more severe treatment would have produced some injury. Guinea pigs are apparently much more likely to be injured by alcohol than fowls.

Elderton and Pearson, who made a careful statistical study of alcoholic parents and children, found that "the general health of the children of alcoholic parents appears on the whole slightly better than the health of the children of sober parents. There are fewer delicate children, and in a most marked way cases of tuberculosis and epilepsy are less frequent than among the children of sober parents. The source of this relation may be sought in two directions. The physically strongest in the community have probably the greatest capacity and taste for alcohol. Further, the higher death rate of the children of alcoholic parents probably leaves the fitter to survive" (p. 31). "To sum up then, no marked relation has been found between the intelligence, physique, or disease of the offspring and parental alcoholism in any of the categories investigated. On the whole the balance turns as often in favor of the alcoholic as of the non-alcoholic parentage" (p. 32).

Cole and Bachuber have found that acetate of lead taken internally seriously affects the sperm cells of the male rabbit, causing the offspring to be weak and underweight, and causing a considerable mortality shortly after birth. In these experiments the litters were in all cases from one mother and two fathers, one of which was poisoned. The colors of the males differed so that the male parent of each young rabbit could be determined at birth. The effect of the lead on the germ cells of the males could be estimated by comparing the young and the relative number of young from each male.

Other agents which have been used with success are the light waves of very short wave length, ultra violet rays, X-rays, and

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radium rays. Guyénot and also Packard have experimented with these, using the fruit fly (Drosophila). The germ cells are much more easily affected than the body cells, though in this case the germ cells seem to be either not affected at all or eliminated completely. Hereditary modifications do not seem to be caused.

The limits of a paper of this nature prevent us from reviewing the extensive literature of this subject. Part of the literature is speculative, part needs repeating or verification in some particular. For our purposes we may make certain statements in conclusion which will serve to summarize the prevailing opinions held by zoologists at the present time as to the status of this very fundamental question. First, it may be stated that no clear-cut proof exists that the bodies of animals normally have any directive or modifying influence on the germ cells or embryos which they contain. Weismann's contentions have been supported, and Lamarck's have been discarded. Second, certain external readily transmitted materials or forces do act directly on the germ cells, eliminating or injuring them in some cases. Inherited injury in this case is not usually comparable to the process known as mutation or the production of new hereditary variations, but rather to a general weakening effect. Third; it is not safe to assume that because one agent causes a certain change in the germ plasm of one animal that it will cause a similar change in another animal.

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THE FABRIC OF OUR PHYSICAL KNOWLEDGE.

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The teacher of physics in the secondary school is frequently so engrossed with a study of the details of physical phenomena that he overlooks the larger meaning of the science, its actual basis in thought and reality, and the fundamental relations of its parts. Certainly a comprehensive view of any science as a whole is as valuable and as important to the teacher as a more intimate acquaintance with its details. Such a view should make the study mean vastly more to the teacher himself, and enable him to present his subject with much more of that degree of understanding to be desired and yet so often found lacking.

Sooner or later both student and teacher of any science must look at the facts of that science as a whole, and ask themselves the question, "What is the actual basis in reality of this intricate construct called a science?" The man of the street says a thing *is*, or *is not*, so *absolutely* because science has proved or disproved it. In this he discloses a naive ignorance as to the significance of science and the meaning of proof, to say nothing of his utter neglect of the fact that scientific knowledge is a mental fabric more or less conditioned by the mind itself. We cannot escape the fact that science is not final, that it is far from it, in fact, and that man's true knowledge of the external world as such can be obtained through no more than five gateways to the mind—the five senses. In the real basis of a science is thus in doubt, its superstructure can be no more substantial. Certainly, the physicist should analyze the situation as fully as possible. He should understand his position as a physicist, and if the principles of psychology and philosophy can be of aid to him he should use them. Too often these subjects suggest infinite terrors to the teacher of physics instead of aiding him very greatly in the fuller criticism of his own position as they really should. If psychology and possibly philosophy are invoked rather freely in the following pages, it is only because of their fundamental connection with physics, which too often passes unnoticed.

Man's sum total of knowledge does not consist of what he *knows* to be absolutely and unqualifiedly true with reference to external reality, but rather it is composed of those mental constructs which are too often taken to be a *complete* representation of external reality.

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It *should* be well known that knowledge of the external world is obtained in only two ways; directly through one's own personal experience or indirectly by accepting the personal experience of others as being as valid as one's own. It is true that man has added much more of a hypothetical nature to these sense data, but this is based upon man's analysis and interpretation of his sense data. The additions exist as realities for us in thought alone. They do not represent perceptual realities, and hence are purely conceptual. A block of wood may exist as an object of perception but the atoms composing it are conceptual. Our body of knowledge is therefore a complex quantity. It is not always easy to separate percept and concept in thought, but in looking at the fabric of scientific knowledge from a critical viewpoint, it is *necessary* to distinguish between the purely perceptual and the purely conceptual (that which exists as a sense-stimulating reality and that which exists in thought alone), in order to have a basis for analysis. The words *real* and *ideal* may serve to distinguish these states, keeping in mind that *real* is used not in the sense of meaning absolutely existent, but in the sense of meaning perceptually possible, while *ideal* refers to that which is not perceptually possible. Both realities and idealities are, to say the least, mind products and conditioned by the mind. Their relation to absolute existence is one thing, and their relation to each other is another entirely different, but obviously more real so far as man is concerned.

Of such materials is science built, and the superstructure of generalization, theory, and hypothesis must be built firmly upon the foundation of actual human experience. This implies that the divisions of physics cannot be haphazard affairs, and their relations to each other cannot be based upon mere superficialities. They must be grounded firmly on the fundamental elements of human experience. Certainly the activities of those who are at present crying loudly for unity of material in the sciences should be conditioned by such facts.

If we are going to evaluate our science in terms of knowledge itself let us look a few moments at some of the general facts concerning knowledge. An apple from my desk is an object of perception, for I know it by sight, taste, and touch. India I recognize as a far distant land because I accept the experience of other beings as I would my own; but an atom and the ether, not being objects of perception by myself or anyone else, are distinctly conceptual in character. The question, "Do I know

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the atom or ether exists?" leads directly to the question, "Do you really know the apple exists, and that India *is* a distant land?" We need not bother with the argument of the idealists versus the realists, and the disagreements of the metaphysicians concerning reality, but we will *accept* a real existence for the objects of our perception and a very close connection between our own mental activities and this ultimate reality. What that connection is, is a question for the metaphysician; the scientist cares only for its conditions.

When I see an apple I have a certain mental image separated in space and time from other mental images. I put out my hand, and my brain speaks up in consciousness through another sense, and says, "Sir, you have touched something smooth and round." My brain might go on noting details, but it has done that before, and so for convenience it winks at me and says, "That is an apple," and you agree of course. What you actually *know* is that you have had certain sense experiences. You *know* nothing of the real existence of the apple. The brain may tell you in five different ways a thing exists, but that does not make it exist. The brain tells a color-blind man that red is green, but that does not make it green. It only makes him know that he sees green.

It is conceivable that a demon such as suggested by Maxwell with power of super-sight would see an apple as a beautiful geometric dance of electrons; while a being with a super-moral sense might see it as an object of moral significance on a plane with the Bible. (It is entirely conceivable that the universal laws of which the apple is in some way an expression, might be so perceived.) What is it then, that to one being appears an apple, to another appears a moral principle, and to another appears a dance of electrons? Evidently it depends upon the *being*, and we are up against the blank wall of ultimate reality again. We do not know what it is ultimately, but we do know that to us it is an apple, red, ripe, mellow, of pleasing flavor, good for food, and we know further that it is the same to each and every normal mind. So much for the apple. Our knowledge of India is one step further removed, and the electron and ether of the physicist seem hazy apparitions indeed.

To the physicist, however, who cares little or nothing concerning ultimate reality, and who cares everything about the sequences and relations of phenomena, the electron is a certainty and the ether an everyday tool of thought. This is because

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science is based upon nothing extra-mental, but upon the five little speeches made by the senses to the brain concerning the objects of perception; and the fact that we have interpreted the data so gathered in just the best possible manner to allow of still further useful and sound interpretation. It is the duty of the physicist to not only realize the physical limitations of his science, but also to realize why he is justified in considering the ether, the electron, and many other conceptions as real enough to use as working tools.

It is difficult for us as we leap through our physics text to look at the mass of material before us in the light of its true value, for it is difficult to definitely separate concepts and percepts, and difficult to keep in mind that the basis of the system lies in sense experience. The first section we note is usually devoted to mechanics. The teacher often naively suggests that this is of extreme importance; but that is a somewhat barren statement. The fact is that this section contains the major part of the direct data of the senses. Here has been put down what we know about matter at rest and in motion, judged by the categories of time and space. Here we see familiar paragraphs on statics, translatory and rotary motion, hydrostatics and hydraulics, and wave and oscillatory motion. Under these heads we have classified our data, analyzed them, and made them the basis for just inferences. The whole structure we have called mechanics for short, and upon this, nearly the whole of what follows is based.

Our senses of sight and hearing and a special quality of touch have acquainted us directly with the phenomena of light, sound, and heat, and thereupon we have established the other common divisions of the ordinary text, but these qualities of sense did little to explain or fully describe what was going on. In reality we always referred these phenomena back to mechanics for a more complete description and one we could more readily grasp and understand. We realize today that it is ridiculous to consider these as natural divisions inherent in the order of things, but that it was our lack of knowledge and our limited perceptive ability which caused us to so order our data; in other words, it was the human element again. However, the body of knowledge thus obtained has enabled us to transcend the powers of sense, and discover electricity, wireless telegraphy, X-rays and radioactivity.

When the magnetic needle moved toward the north, the turn

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of a switch started a motor, and the press of a key sent an invisible signal across the ocean, we were compelled to add the extra divisions, magnetism, electricity, and radiation, to the body of our growing science. The phenomena thus included did not follow the known laws of the commoner divisions of physics, and we had to invent explanations. In mechanics we had to invent very little; the subject was almost purely descriptive. In heat, light, and sound, we had to fill in many perceptual gaps with mechanical concepts, to enable us to go forward, but when it came to electricity, and magnetism, besides building on the concepts of mechanics, heat, light, and sound, we still had a multitude of gaps to fill with conceptual figments. Science is today still busy filling these gaps to the best of her abillty with theories and hypotheses which will not only harmonize with perceptual facts but which will form the basis for future reliable inferences. It is only possible to do this through the shortened methods of symbolism better known as mathematics. It is the physicist's dependence upon mathematics which has given the mathematician a chance to playfully affirm that physics is only an offshoot of mathematics. Certainly, the relation between the two subjects grows closer as both proggress. The answer to the affirmation, which no matter how playfully made contains an undoubted truth, lies in the fact that mathematics is no other than richly developed symbolic logic, and physics to be rational must put itself completely in the hands of logic. So it is that we use our mathematics to enable us to organize to the highest point our data, and to enable us to use this organization to do the most reasonable and useful things possible. Hence our system is rational per se, and if the conceptual facts demand the existence of the electron, and if experiment proves the validity of such conclusions so far as perceptually possible, and if such a concept enables us to make progress and discoveries otherwise impossible, then the scientist assumes its real existence, no matter what the metaphysician has to say. All the scientist has to do is to keep his mind open and remember that an altogether sound framework cannot well be built upon a foundation which is not itself ultimate, and that he has done the best he can. How shaky is the framework then, and how fictitious are our concepts?

When I push a block of wood it moves. When the magnet moves a needle I make a mental compromise and say *something* pushed or pulled it. When I see a certain color I believe it to

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result from matter or motion. I gain a little perceptual evidence, and say it must be a motion; I gain a little more perceptual evidence, and I say it is not like a longitudinal wave in a spring, it must be something transverse like a water wave, and by rapid methods of reasoning, using the various mental economics of mathematics, I say it must be a certain form of that with which I am otherwise familiar, and if this is true, other things are true because they have been true at other times. Being a wave it must be a wave of something. Now if we assume a *something* and call it the ether, it must work according to the fact of our real knowledge, else we need not assume it. The only reason we assume it in the first place is in order to permit us to have a tool to think with, and one that will enable us to think in the right direction. J. Clark Maxwell gave us our ether of today. Previously, ethers had been suggested, but with too hard and fast material properties to make them applicable to all conditions. That was Maxwell's accomplishment, to give us a mathematical concept that covered the perfectly general case, upon which rapid development could be made. Maxwell's ether is a *reality*, that is, it is a concept which has proved its own value, and its own application to physical problems. It is not a reality in the sense in which the term was introduced in this article. It is not perceptually possible, and the modern followers of the action-at-a-distance theory would have us believe there is no ether at all. However that may be, Maxwell never intended to answer such universal riddles as to what is ether, matter, electricity, etc.? He only attempted and succeeded in showing us how electricity and matter interact, and that such interactions occur just as if there was an intervening ether which obeyed simple mechanical laws. It was an epochal achievement, and Maxwell's fame will never grow dim. The outline growth of this concept is typical of all. Sometimes a conceptual body approaches closely the border line dividing concept and percept, as the electron has done through brilliant experiments such as Millikan's. But no matter how near it comes it is still a long way off, and other concepts as that of the ether seem no nearer a perceptual justification now than a thousand years ago. It is as if the scientist had climbed to his present height upon a pile of boxes. He cannot quite justify his position, because he made the boxes himself, and he cannot kick out any beneath him for they have put him where he is and the structure would then collapse. The results alone justify the position and the necessary, inseparable connection of all the elements of the structure is apparent.

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Such considerations do not discount the value of physics but rather do exactly the opposite, for they enable one to see better just what the science is that he is working with, and just wherein its true value lies. Though the basis of physics exists in sense perception, man has been able through his intellectual power to transcend the limits of the senses. Our knowledge of physical laws and phenomena greatly surpasses perceptual possibility. And though physics as a science does not pretend to be ultimate, it seems at least that through it we are approaching a realization and appreciation of the ultimate universe, and its ultimate laws.

A PLATINUM "FAKE" IN OREGON.

The present shortage of platinum and the consequent greatly increased price of the metal bid fair to result in a considerable increase in the domestic production of platinum during the coming year. At the same time, while legitimate miners are increasing their production and to some extent relieving the country's shortage, other persons are using the interest aroused by the present nation-wide search for the metal to make extravagant claims for utterly worthless deposits, and some honest prospectors are led by false assays, made by inefficient or venal assayers, to believe mistakenly that they have valuable platinum deposits. Reports of platinum in some mythical combination—"volatile platinum" or "colloidal platinum"—should be regarded as sufficient evidence of the incompetence or dishonesty of the assayer.

During the season of 1917 the geologists of the United States Geological Survey, Department of the Interior, spent much time in visiting platinum deposits that proved to be worthless. A notable example is seen in the supposed platiniferous sands of the Deschutes River, near Terrebone, Ore., which were examined by H. G. Ferguson in October, 1917. Claims have been staked for several miles along Deschutes and Crooked Rivers, and as certain volcanic sands along these rivers had been said to contain large percentages of gold and rare metals, particularly metals of the platinum group, Mr. Ferguson visited the localities at which the sands were obtained and took samples for test and analysis.

The material collected, which is exposed in the canyon of the Deschutes River north of Low Bridge in Sec. 15, T. 14 S., R. 12 E., consists of loosely cemented dark volcanic sand and conglomerate interbedded with basalt and volcanic tuff. The black basaltic sand is supposed to have the richest content of gold and platinum, but neither in panning the material in the field nor in the chemical tests made by the Geological Survey could any trace of platinum or other metals of the platinum group be found. Neither was any gold found in the concentrates, and it is concluded that material of this type is very unlikely to contain workable amounts of gold.

In conclusion, the Geological Survey desires to warn prospectors and investors against accepting at their face value any statements in regard to platinum-bearing ores and sands that do not show native platinum when panned. Such material should always be sent to assayers whose reputation is above reproach.

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HELP YOUR GOVERNMENT.

You may not be able, for good reasons, to go to the front and fight for your country; but you have often wanted to do something more for your country in time of war, and wondered how you could be of further service.

This letter is to tell you how you may serve your country NOW and all the time, and at the same time help yourself, help your children, and those who are near and dear to you.

The Government has extended the opportunity to aid in the successful financing of the war to every man, woman, and child in the United States. It wants everyone as a partner in the fight for democracy. For this purpose it has devised the WAR SAVINGS plan. Under it you can lend money to your Government by buying Thrift or War Savings Stamps, as little as twenty-five cents, and as much as $1,000—but no more.

There are two kinds of stamps, $5 War Savings and 25-cent Thrift Stamps. The War Savings Stamps sell from $4.12 to $4.23, according to the month in which purchased. These stamps are now on sale at every post office and sub-post office, most of the banks, and many other agencies. They are easy to buy, and are the most profitable Government loan offered to the public. Their return is equivalent to four per cent interest compounded every three months.

The Government wants you, your children, and all of your household to purchase stamps from your SURPLUS earnings—not what you have accumulated in the past, but what you can save in the future. It asks you to do without some of the things you think you want, and lend it the money you thus save. It wants you to be thrifty, so that you and your country may profit by your thrift.

If you give War Savings Stamps to your children you give something that will not only increase in value, but will induce them to save their pocket money in the coming year, and buy more. You will be teaching them a lesson in thrift, and letting them know that they, too, may serve their country.

If you make presents of these Stamps, besides aiding your country directly, you give indirect aid in that all labor employed in making the articles you think you need and don't, will be released to aid in the work of preparing the things the nation actually needs in the conduct of the war.

REPORT OF THE DIRECTOR OF THE BUREAU OF STANDARDS.

Standardization is the keynote of the annual report recently made public by the Director of the National Bureau of Standards: "The Bureau occupies somewhat of the same position with respect to the manufacturing interests of this country that the bureaus of the Department of Agricultural do to the agricultural interests. Many industries are just beginning to realize the importance of precise methods of measurement and scientific investigation, which, in practically every case, involve some kind of measurement."

The services of the Bureau are in great demand and many researches have been completed or are in progress on points fundamental to the industries. "It is upon quality as well as upon price that competition must finally depend, whether in domestic or foreign commerce. The use of exact methods and scientific results is the greatest factor in the improvement of quality, efficiency, or the development of new industries. The educational value of the Bureau's work in this respect is almost entirely unknown to the general public, and yet the Bureau receives hundreds of letters, as well as many personal visits from manufacturers, seeking

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information as to standards of measurement, how to use them, how to measure the properties of materials, or as to the fundamental, physical, and chemical principles involved; also, what is of even greater importance, how to initiate and carry out scientific investigations and tests on their own account in their particular fields of work."

The bulk of the report is devoted to a description of the investigations completed and in progress in the scientific and technical divisions of the Bureau.

In connection with the testing of railroad track scales the report states: "The Bureau has been cooperating in this work with the state and municipal weights and measures officials, with the weighmasters, manufacturers, railroads, private individuals, and other departments of the Federal Government, and steady progress is being made toward securing adequate standards in railroad track scale testing." Tests were made in twenty-eight states. "In these states 325 scales have been tested, of which 201, or 61.8 per cent, failed to pass the tolerance in condition in which they were found. The tolerance used by the Bureau is based on a maximum permissible error of weighing of 200 pounds in weighing a car of 100,000 pounds gross weight."

The Bureau's researches in heat included also important work upon the fire resisting properties of materials to furnish to architects, construction engineers, builders, state and city building bureaus, insurance interests, and others with fundamental engineering data relating to the behavior and safety of various types of building materials and construction when exposed to different conditions met with fires. Fire tests will be made of structural steel columns and reinforced concrete columns. Equipment of unusual interest installed during the year is the panel testing furnace which will be utilized for testing the fire resisting properties of building partitions and walls. In this connection a work of general interest is the investigation and formulation of data as to the building codes of the various states and cities.

The electrical testing included the inspection and testing of 1,250,000 electric lamps, a great variety of light standards, electrical instruments, standards, and materials. A matter of unusual interest has been the investigation and development of an instrument for finding the production of radio signals and using it for promotion of safety at sea.

JOHN C. WINSTON COMPANY, PUBLISHERS.

The John C. Winston Company of Philadelphia announces that it will enter the schoolbook field on the 1st of January. For several years this company has been preparing a series of textbooks under the editorship of Dr. William Dodge Lewis, Principal of the William Penn High School of Philadelphia. James G. Stradling, for many years connected with The American Book Company, will be the salesmanager of this new Educational Department.

In the selection of authors and the treatment of the various subjects, Dr. Lewis has had the advice and active cooperation of a number of leaders in modern educational thought. Among them may be mentioned B. M. Watson, Secretary of the Public Education Association of Philadelphia, former Superintendent of Schools, Spokane, Wash.; Harold Barnes, Principal of the Elementary School, Girard College; and Dr. J. Lynn Barnard of the Philadelphia School of Pedagogy, a member of the National Education Association Committee on Social Studies.

The Winston Company, which in thirty years' experience has acquired a long list of publications, among which are many notable titles, has entered the educational field with a sincere effort to make a distinct contribution to textbook literature.

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ROCKS OF THE GRAND CANYON.

The visitor who looks into the Grand Canyon from the vicinity of El Tovar may, when the first overpowering impressions give place to particular observations, note the great series of nearly horizontal rock layers whose varied colors and cyclopean carving give beauty to what might otherwise be a gloomy and terrifying sight. He may perhaps wonder how these beds of rock were formed, how thick they are, and how long it took for them to pile up, inch by inch, on the bottom of a now vanished sea. He is not likely, however, unless he is a trained observer, to have his attention attracted by the dark, less conspicuous rocks in the very bottom of the canyon or to see that these are very different in many ways from the stratified rocks above them. Yet these rocks—mostly tough crystalline granite gneiss and schist—which the river, after cutting through thousands of feet of overlying beds, is now battering and grinding with its boulders, have an interesting story for those who may be able to read it. They are the oldest rocks in the canyon and, in fact, among the oldest in the world. They were in part deposited as sands and muds in a sea, in part accumulated as lava flows, and in part intruded beneath the surface as molten rock. All these materials became solidified, and later they were slowly heaved and crumpled into mountains which were in time worn down by rain, rivers, and perhaps the waves of the sea to a nearly level land surface. This surface finally sank beneath the sea and became the floor on which fresh sediments began to accumulate. Twice at least was this mighty cycle repeated in the Grand Canyon region.

Recently, in an attempt to work out some of the details of this ancient history, L. F. Noble, one of the geologists of the United States Geological Survey, Department of the Interior, studied them at several places on the south side of the river where, often with considerable difficulty, he was able to get down to them. His collections were studied microscopically by another member of the Survey, J. F. Hunter.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for November; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "Fruit of the Potato," Willard N. Clute; "Uses of the Bayberry," Albert A. Hansen; "The Hawaiian Taro," Vaughan MacCaughey.

American Journal of Botany, for December; *Brooklyn Botanic Garden, New York City; $5.00 per year, 60 cents a copy:* "The Phytogeography of Manoa Valley, Hawaiian Islands," Vaughan MacCaughey; "Revision of the Hawaiian Species of the Genus Cyrtandra, Section Cylindrocalyces Hillebr," Joseph F. Rock; "On the Distribution of Abnormalities in the Inflorescence of Spiraea Vanhouttei," J. Arthur Harris.

Geographical Review, for December; *New York City, $5.00 per year, 50 cents a copy:* "Flanders," Raoul Blanchard; "A Journey on the Rio Zamora, Ecuador," J. L. Hermessen; "The Yuracaré Indians of Eastern Bolivia," Leo E. Miller; "The Peoples of Hungary," B. C. Wallis.

Journal of Geography, for January; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Humanizing High School Geography," Richard E. Dodge; "A Geographer's Geography Lesson On the Prairies," Albert P. Brigham; "Suggestions for Teaching Elementary Geography" (concluded), R. H. Whitbeck; "Prussianized Germany" (reprinted), Otto H. Kahn; "The Importance of Geographic Factors in the Birmingham, Ala., Iron District," Charles W. Cook; "Measuring the Ability of Children in Geography," E. E. Lackey; "Geography in the Junior High School," James H. Smith.

Literary Digest, for January 5; *New York City:* "The Government

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Forced to Take the Railroads," "The Truth at the Bottom of the Sugar Barrel," "To Win the War with American Coal." For January 12: "Why Our Soldiers Wait for Clothes," "The Brewers' Campaign of Righteousness (?)," "A Peace Offer Distrusted by Both Sides."

Photo-Era, for January; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Exhibitions and Exhibitors," Sigismund Blumann; "Panoramic Cameras and Panoramic Perspective," Harold Munday; "Experiences in Amateur-Portraiture," Ralph Osborne; "On Stopping Down," Thomas Kingham; "Direct-Mail Methods for Photographers," Michael Gross; "Photographing Frost," R. A. Buchanan; "Making the Still-Life Picture," W. R. Bradford; "Buying a Second-Hand Lens," T. D. Percival.

Popular Astronomy, for January; *Northfield, Minn.; $3.50 per year:* "Beneath Midwinter's Starlit Dome," Charles N. Holmes; "Twenty-first Meeting of the American Astronomical Society," Concluded; "A Short Method of Utilizing Coincidence of Beats in Comparing and Setting Clocks," Charles C. Wylie; "A Reply to Professor Flint's Article, 'The American Ephemeris Tables of the Times of Rising and Setting of the Sun and the Moon—A Review,' " Arthur Newton; "Report on Mars, No. 19," William H. Pickering.

The Psychological Clinic, for December; *Philadelphia, Pa.; $1.50 per year, 20 cents a copy;* "A Brief Binet-Simon Scale," Edgar A. Doll; "A Case of Educational Retardation," Charles L. Harlan.

School Review, for January; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Foreign Languages and Mathematics as Requirement for Admission to, and Graduation from, American Colleges and Universities," E. E. Lewis; "The Social Core of the High-School Curriculum," Herbert G. Lull; "Elimination from the Public Secondary Schools of the United States," Frank G. Pickell and B. F. Winkelblech.

School World, for December; *Macmillan Company, London, Eng., 7s. 6d. per year:* "The Adjustment of the Secondary-School Curriculum, Walter Ripman; "How to Write with the Left Hand, II; The Characteristics of Left-Handed Script," P. B. Ballard; "Educational Aspects of the Kinematograph," H. O. Hale.

SOAP PLANTS.

Now that the war has caused an increase in even the price of soap grease, a lively interest is being manifested in all sorts of saponaceous plants. One or two of these soap-yielding species have been articles of commerce for a long time, notably the soap bark derived from the South American trees, *Pithecolobium bigeminum* and *Quillaia saponaria*. A stock of this bark is carried by most drug stores. The soapberry (*Sapindus saponaria*) is also used for washing clothes in the tropics, but a little soap goes a long way in such places. The common bouncing Bet (*Saponaria officinalis*) gets its generic name from the soapy qualities of its juice, while its specific name would indicate that at some time it, too, was sold in shops. The substances in plants that give them their saponaceous qualities are called saponins. They are really glucosides, that is, substances which upon breaking up yield sugar and some other substance. With water all saponins form a froth or lather. Some are occasionally added to certain frothy liquids to help out the froth, incidentally making a barrel of the liquid last longer. Saponins have been found in more than a hundred species of plants. Among the plant families represented by saponaceous members are the Liliaceae, Dioscoreaceae, Araceae, Chenopodiaceae, Phytolacaceae, Caryophyllaceae, Berberidaceae, Magnoliaceae, Ranunculaceae, Bixaceae, Theaceae, Rutaceae, Zygophyllaceae, Meliaceae, Polygolaceae, Pittosporaceae, Rhamnaceae, Saxifragaceae, Passifloraceae, Bignoniaceae, Leguminosae, Primulaceae, Sapotaceae, Oleaceae, Solanaceae, Schrophulariaceae, Rubiaceae, and Compositae.—|*American Botanist.*

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

536. *Proposed by Daniel Kreth, Wellman, Ia.*

Five gamblers, A, B, C, D, E. play together on the condition that he who loses shall give to each of the others as much as he already has. First A loses, then B, then C, then D, and finally E. At the end of the fifth game each has \$32. How much had each before they began to play?

I. *Solution by William F. Rigge, Omaha, Neb.*

Let the original amounts possessed by the players be respectively a, b, c, d, e. As the total sum is always the same, it follows that

$$a+b+c+d+e = 5\times 32 = 160 \text{ dollars.}$$

Then the horizontal data in the following schedule will show in reduced form the successive fortunes of each player, the vertical columns giving the results after each game.

		1	2	3	4	5	
A	a	$2a-160$	$2(2a-160)$	$4(2a-160)$	$8(2a-160)$	$16(2a-160)$	$=32$
B	b	$2b$	$4b-160$	$2(4b-160)$	$4(4b-160)$	$8(4b-160)$	$=32$
C	c	$2c$	$4c$	$8c-160$	$2(8c-160)$	$4(8c-160)$	$=32$
D	d	$2d$	$4d$	$8d$	$16d-160$	$2(16d-160)$	$=32$
E	e	$2e$	$4e$	$8e$	$16e$	$32e-160$	$=32$

In this way the values of the five unknowns are easily found, being respectively, 81, 41, 21, 11, 6.

The problem may be generalized by letting n = the number of players, and m = the equal sum each has at the end. Then

$$a+b+c+d+e = mn.$$

At the end of the game we have the above fifth column modified into

$$\begin{array}{rcl|l|rcl} 16(2a-mn) & = & m & & a & = & (2^4n+1)m/2^n \\ 8(4b-mn) & = & m & & b & = & (2^3n+1)m/2^n \\ 4(8c-mn) & = & m & \text{whence} & c & = & (2^2n+1)m/2^n \\ 2(16c-mn) & = & m & & d & = & (2n+1)m/2^n \\ 32e-mn & = & m & & e & = & (n+1)m/2^n \end{array}$$

If m is taken equal to 2^n, it will have its minimum integral value. This has been done in the present problem.

If we now add up our values of a, b, c, d, e, we get

$$mn = n(1+2+2^2+2^3+2^4)+n$$

$$\text{or } m = (1+2+2^2+2^3+2^4)+1.$$

The parenthesis is a geometrical progression, in which, in general, if a is the first term, r the ratio, and n the number of terms, then s, their

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sum, equals $(ar^n-a)/(r-1)$, so that in this case the parenthesis is equal to 2^n-1, and $m = 2^n$, as said before.

If we take seven players, $n = 7$, and $m = 2^7 = 128$, the lowest integral number of dollars that can be possessed by the players at the end of the game. Two terms are then to be added to the five former ones, 2^5n+1 and 2^6n+1, so that the original sums must be 449, 225, 113, 57, 29, 15, 8. This is the problem as it is given by Loomis in his *Treatise on Algebra* (*1881*), page 112 (No. 12) where, however, instead of players and dollars, he uses seven baskets of apples, taking apples from each basket in turn and with them doubling those in the other baskets.

II. *Solution by Gertrude Buck, Adrian, Mich.*

Let a, b, c, d, and e represent the number of dollars owned before the game by A, B, C, D, and E, respectively.

Then

$16(a-b-c-d-e)$ = the amount held by A at close of 5th game.
$24b-8(a+c+d+e)$ = the amount held by B at close of 5th game.
$28c-4(a+b+d+e)$ = the amount held by C at close of 5th game.
$30d-2(a+b+c+e)$ = the amount held by D at close of 5th game.
$31e-(a+b+c+d)$ = the amount held by E at close of 5th game.

Since at the close of the game each has \$32 we have the system of equations formed by making each of these sums equal to 32.

Then

$$\begin{aligned} a-\ b-\ c-\ d-\ e &= 2 \\ -a+3b-\ c-\ d-\ e &= 4 \\ -a-\ b+7c-\ d-\ e &= 8 \\ -a-\ b-\ c+15d-\ e &= 16 \\ -a-\ b-\ c-\ d+31e &= 32 \end{aligned}$$

Solving these equations we find

$$a = 81, \quad b = 41, \quad c = 21, \quad d = 11 \quad \text{and} \quad e = 6.$$

III. *Solution by Arthur Bergman, Milwaukee, Wis.*

After the 5th game each gambler had \$32.00.
After the 4th game A, B, C, and D, each had \$16.00.
After the 3rd game A, B, and C, each had \$8.00.
After the 2nd game A and B had \$4.00.
After the 1st game A had \$2.00.

Let a, b, c, d, and e be the amounts A, B, C, D, and E, respectively, had before they began to play.

$\therefore$ From above

$$a+\ b+\ c+\ d+\ e = \$160 \qquad (1)$$

As a result of the 1st game A had \$2, while each of the others doubled his amount.

$$\therefore \quad 2+2b+2c+2d+2e = \$160 \qquad (2)$$

As a result of the 2nd game A and B each had \$4, while each of the others doubled his amount.

$$\therefore \quad 4+4\ +4c+4d+4e = \$160 \qquad (3)$$

As a result of the 3rd game A, B, and C each had \$8, while each of the others doubled his amount.

$$\therefore \quad 8+8\ +8\ +8d+8e = \$160 \qquad (4)$$

As a result of the 4th game A, B. C, and D each had \$16, while E doubled his amount.

$$\therefore \quad 16+16+16+16+16e = \$160$$

$$\therefore e = \$\ 6$$

By substitution, from (4) d = \$ 11
By substitution, from (3) c = \$ 21
By substitution, from (2) b = \$ 41
By substitution, from (1) a = \$ 81

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IV. *Solution by Murray J. Leventhal, New York City.*

At the end of the fourth game, each of the first 4 gamblers evidently had \$16 and E, $32+4\times16 = 96$. Since E's amount is halved at the end of each preceding game, his initial sum $= 96/2^4 = 6$. At the end of the 3rd game, A, B, C have \$8 each. D, therefore, has $48+3\times8+16$ or 88; his first sum $= 88/2^3 = 11$. At the end of the 2nd game, C's share $= 44+24+2\times4+8 = 84$ and his original sum $= 84/2^3 = 21$. Similarly, A and B had \$81 and \$41, respectively, before they began to play.

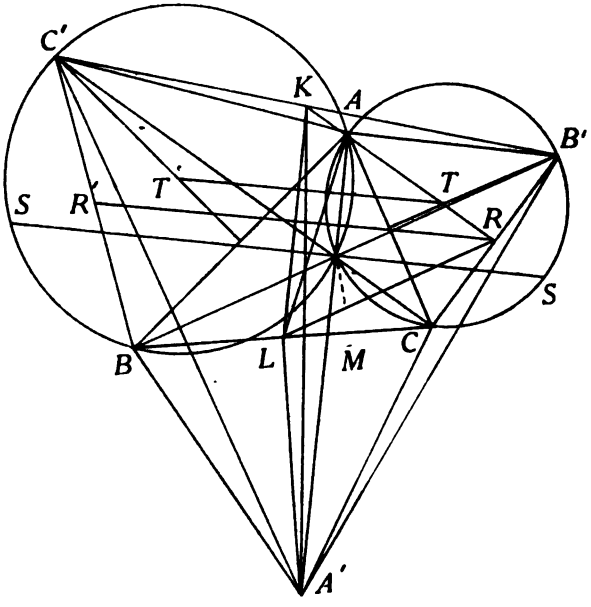
Solutions to this problem were also received from *Ruth A. David, Isidore Ginsburg, J. W. Holman, Caroline Lefkowitz, Mabel McLaughlin, Sidney Nierman, Nelson L. Roray* (2). One solution with unknown author—*please read and observe rules* published in earlier numbers. —*Editor.*

Geometry.

537. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Equilateral triangles are constructed outwards upon the sides of any triangle. Prove by elementary geometry only that the given triangle and the triangle whose vertices are the outermost vertices of the equilateral triangles have the same median point.

Solution by Nelson L. Roray, Metuchen, N. J.



Let ABC be the given triangle; A', B' and C' the vertices of the constructed triangles; T the circumcenter of AB'C, T' of ABC'; AL median of ABC, A'K of A'B'C'; R mid point of B'C, R' of BC'; S mid point of arc B'C, S' of BC'; M the point of intersection of AA', BB' and CC' (Problem 348, Nov., 1913).

Then $TT' \perp AM$, $TT' \parallel SS'$ and $RR' \parallel SS'$ $\therefore RR' \perp AM$. (1)

$KR \parallel CC'$ and $KR = \frac{1}{2} CC'$; $LR \parallel BB'$ and $LR = \frac{1}{2}BB'$ (2)

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$\therefore \angle KRL = \angle C'MB = 60°$.

Since KRLR' is a parallelogram KL and RR' bisect each other, also $\angle KRR' = \angle SMC = 30°$.

$\therefore \triangle KRL$ is equilateral. (3)

and $RR' \perp KL$ and $KL \parallel AA'$, from (1).

If Z is mid point of AC and Z' of A'C,

$\triangle ZZ'C \cong \triangle LCR$ and $ZZ' = LR \therefore AA' = BB'$. (4)

and $AA' = BB' = CC'$ from (2). (3) and (4).

Since $KL = LR = \frac{1}{2}BB'$

$\therefore KL = \frac{1}{2}AA'$

$\therefore$ In trapezoid KLAA' LA and KA' trisect each other and this point of trisection is the median point of each triangle.

538. *Proposed by N. P. Pandya, Sojitra, India.*

Construct a triangle ABC, having given angle B, median from C on AB, and the angle between the median and the perpendicular from A on BC.

I. *Solution by Ruth A. David, Gibson City, Ill.*

Let m be the given median, and $\angle x$, the acute $\angle$ between the median and the $\perp$ from A on BC.

Construction:

1. Construct $CE = m$.
2. Construct $\angle ECH$ equal to the complement of $\angle x$.
3. At any point H in line CH construct $\angle CHG$ = given $\angle B$.
4. Through E construct a $\parallel$ to HG meeting CH at B.
5. Extend BE to A, making $EA = BE$.
6. Draw AC.

Triangle ABC is the required $\triangle$.

The proof follows easily from the figure.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Construct $\angle MBN = \angle B$. Upon side BN construct $NR \perp BN$. At S, any point on NR, construct $\angle TSN$ = angle formed by median and perpendicular. Let TS intersect BM at T and BN at E. (Angle TSN must be obtuse for the problem to be possible as is easily proved.)

Then construct $\triangle T'E'B'$ with $T'E'$ equal to given median, $\angle E' = \angle E$, and $\angle T' = \angle T$ of $\triangle TEB$. Evidently $T'B' = \frac{1}{2}AB$, $B'S' = BC$ and the rest of the construction follows at once.

Note: This method holds whether $\angle B$ is acute, right or obtuse, but $\angle TSN$ must always be obtuse.

III. *Solution by Murray J. Leventhal, New York City, and Joe Kuckuck, Martin's Ferry, O.*

Let altitude AE and median CD meet in F. Whether $\angle BCA$ is acute or obtuse, $\angle FCE$ is the complement of the given $\angle AFD$. $\therefore \triangle BCD$ is easily constructed (2 sides and the included $\angle$). Now make $DA = BD$, and join A to C. The proof is evident from the diagram.

539. *Proposed by Sam I. Jones, Nashville, Tenn.*

Given an angle and a point without its sides to draw through the point a line cutting the sides of the angle, forming a triangle whose perimeter equals the length of a given line.

Solution by E. L. Brown, Denver, Colorado, Nelson L. Roray, Metuchen, N. J., and Murray J. Leventhal, New York City.

Let AM, AN be the two given lines, and P the given point.

Measure off AD on AM and AE on AN so that $AD = AE = S$. one-half length of given line.

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Let O be center of circle tangent to AM and AN at D and E, respectively.

Through P draw a line tangent to circle at T and cutting AM in B and AN in C; this tangent line to lie between A and O.

ABC will be the triangle required.

$AB+BT = AB+BD = s$

$AC+CT = AC+CE = s$

$\therefore AB+BT+TC+AC = AB+BC+AC = 2s.$

540. *Proposed by Daniel Kreth, Wellman, Ia.*

Construct the triangle if the three radii of the escribed circles are given.

I. *Solution by E. L. Brown, Denver, Colorado.*

We will assume relations expressed by (1), (2), (3).

$$r = \frac{\triangle}{s}, r_1 = \frac{\triangle}{s-a}, r_2 = \frac{\triangle}{s-b}, r_3 = \frac{\triangle}{s-c}. \quad (1)$$

$$\frac{1}{r} = \frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3} \ldots (2) \qquad \triangle = \sqrt{rr_1r_2r_3}. \quad (3)$$

Since r_1, r_2, r_3 are given, r may be constructed as follows: Let A, B, C, be three points on a straight line. On same side of this line erect $\perp$s AD, BE, CF, equal, respectively, to r_1, r_2, r_3.

From G, intersection of AE and DB, drop GH $\perp$ to AC.

From K, intersection of GC and HF, drop KL $\perp$ to AC.

It is easily proved that

$$\frac{1}{GH} = \frac{1}{r_1}+\frac{1}{r_2}, \text{ and } \frac{1}{KL} = \frac{1}{GH}+\frac{1}{r_3} = \frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}.$$

$\therefore$ KL = r, radius of inscribed circle.

From (2) and (1),

$$\frac{1}{r}-\frac{1}{r_1} = \frac{1}{r_2}+\frac{1}{r_3} = \frac{s-b}{\triangle}+\frac{s-c}{\triangle} = \frac{a}{\triangle}. \quad (4)$$

$$\therefore a = \triangle\left(\frac{1}{r_2}+\frac{1}{r_3}\right) = \triangle\left(\frac{1}{r}-\frac{1}{r_1}\right). \quad (5)$$

From (3) and (5),

$$a = \sqrt{rr_1r_2r_3}\left(\frac{r_2+r_3}{r_2r_3}\right) = \sqrt{rr_1r_2r_3}\left(\frac{r_1-r}{rr_1}\right).$$

$$\left.\begin{array}{l} \therefore a^2 = (r_2+r_3)(r_1-r) \\ \text{Similarly, } b^2 = (r_3+r_1)(r_2-r) \\ \text{and } c^2 = (r_1+r_2)(r_3-r) \end{array}\right\} \quad (6)$$

Hence, sides of required $\triangle$ are mean proportionals between sums and differences of radii of inscribed and escribed circles, as indicated in (6).

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let r_1, r_2, and r_3 be the radii of the escribed circles upon the sides a, b, and c, respectively; r the radius of the incircle, I its center; R the radius of the circumcircle, S its center.

The following well known formulae enable us to determine r, R, $\angle C$ and SI.

$$\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3} = \frac{1}{r}$$

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$r_1+r_2+r_3-r = 4R$

$r+r_1+r_3-r_2 = 4R\cos C$

$SI^2 = R^2-2Rr.$

Construct angle = $\angle C$; then circle, center I, of radius r, tangent to the sides of $\angle C$. With SI as radius and center I construct a circle. This circle is locus of S with respect to I. With C as center and radius SI construct a circle (locus of S with respect to C). The intersection of these locii determines S. The rest of the construction follows at once.

Note: The two locii in general intersect in two points giving two circumcenters. The two triangles formed, however, will be congruent.

Solution Received.

A solution to 528 was received from N. P. Pandya too late for publication.

PROBLEMS FOR SOLUTION.

530. *Proposed by N. P. Pandya, Sojitra, India.*

(*This is repeated—no solutions received.—Ed.*)

If $\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta$, find $\sin 2\theta+\cos 2\theta$.

Algebra.

551. *Proposed by Murray J. Leventhal, New York City.*

Show that the sum of the squares of the reciprocals of the natural numbers is $\frac{1}{6}\pi^2$.

Geometry.

552. *Proposed by Norman Anning, France.*

Given a regular n-gon, to construct a regular $2n$-gon having the same center and the same length of side.

553. *Proposed by W. W. Gorsline, Chicago.*

Of all possible triangles inscribed in a given segment the isosceles triangle has the maximum perimeter.

554. *Proposed by the Editor.*

Prove by a direct method that if two angle bisectors of a triangle are equal the triangle is isosceles.

[This theorem being a familiar one, a recently published solution by Dr. Artemas Martin in the *American Mathematical Monthly* attracted our attention and it is desired to make a collection of different direct methods. Send also copied methods (with references).—*Editor.*]

Trigonometry.

555. *Proposed by Daniel Kreth, Wellman, Ia.*

Determine a point P within a triangle ABC such that the angles PAB, PBC, PCA, shall be equal.

The special campaigns in the South for the increased production of foodstuffs through the extension forces resulted in a marked increase in the planting of corn, soy beans, velvet beans, cow-peas, peanuts, sweet potatoes, Irish potatoes, and other food crops. The corn crop in the fifteen Southern States was 964,504,000 bushels, or more than a fourth of the whole crop of the United States.

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SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your first term examination papers now.*

Examination Papers.

A number of years ago the Editor of this department collected examination papers in physics from about one hundred high schools. These papers were edited, and selected questions to the number of 370 were published—credit in each case being given—as the Appendix, pp. 389-422, to Crew & Jones' *Elements of Physics*. The collection of examination papers by that method requires a large expenditure of time and some expense.

Readers of SCHOOL SCIENCE AND MATHEMATICS are again urgently requested to send their first semester examination papers to the Editor. He hopes to publish many papers, especially such as will be suggestive not only in physics, but in chemistry, biology, general science, etc.

PLEASE HELP!

Questions and Problems for Solution.

291. *Proposed by the Editor.*

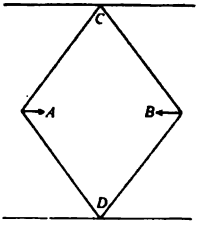
I. Which is the method to be preferred in testing the results of physics teaching:

(*a*) That of the School Survey which seeks to find out whether or not the subject is being taught successfully, or

(*b*) That of practice tests such as Courtis in arithmetic and Rugg and Clark in algebra?

II. Is it correct to say that (*a*) tests *knowledge* and (*b*) *attainment*?

III. In proposing physics tests, what *abilities* do we wish to investigate?



292. *Proposed by J. P. Drake, Emporia, Kan.*

If all the arms are of equal length, find thrust in each arm when angles at C and D are 60°. Also find force tending to separate C and D.

293. *Asked by O. L. Brauer, Selma, Cal.*

Have any data been published as to how the radiation from a hot sphere varies with the time?

294. *From "An Elementary Study of Chemistry," by McPherson and Henderson (Ginn & Company, 1917).*

The heat evolved in the slacking of 100 kg. of lime would raise the temperature of what weight of water from room temperature (say 18°) to boiling?

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Solutions and Answers.

266. *Proposed by A. H. Smith, Riverside, Cal.*

The nozzle of a fire hose has an opening 2 in. in diameter while the pipe just back of it is 3 in. in diameter. Find the pressure just back of the nozzle when it can throw a jet 60 ft. vertically upward.

Solution by J. P. Drake, Emporia, Kan.

Let v_1 = veloc. in 3 in. tube.
v_2 = veloc. in 2 in. tube.
m = mass of water.
Neglecting atmospheric pressure,

1. $mgh + 1/2\ mv_1^2 = 1/2\ mv_2^2$.
2. $v_2^2 = 2 \times 32.2 \times 60 = 62.2$ ft. per sec.
3. $v_1 = \left(\frac{2}{3}\right)^2 \times 62.2 = 27.64$.
4. Substituting in 1.

$gh + 382 = 1{,}932$.
$\therefore h = 48+$.

$$\therefore \text{pressure} = \frac{48}{144} \times 62.4 = 20.8+ \text{ lbs. per sq. in.}$$

Since this pressure is opposed to atmospheric pressure, the absolute pressure = 20.8+ + 14.7 = 35.5+ lbs. per sq. in.

270. *Proposed by William T. Reed, Woodlawn, Pa.*

Will a boat sunk in midocean ever reach the bottom? If it does reach the bottom, what principles of physics are involved? If it does not reach the bottom, state why.

Answered by F. T. Jones.

The boat will reach the bottom if its specific gravity exceeds that of the sea water at the depth. Water being only slightly compressible, its specific gravity is always less than 2. At a depth of two miles the specific gravity of sea water is about 1.4. The principle is that of Archimedes, namely, that any body will sink in a liquid of lower specific gravity because it displaces a weight of liquid less than its own weight. Hence, there is a resultant force downward.

272. *Proposed by Ross A. Baker, Minneapolis, Minn.*

What volume of H_2SO_4 (sp. gr. = 1.84) and what weight of NaCl would be required to produce the HCl present in 8 kgm. of a 3 per cent solution of HCl?

Solved by the Editor.

8 kgm. = 8000 gm.
$8000 \times .03 = 240$. gm. wt. of HCl formed.
Assuming a high temperature,

$$H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl.$$
$$98 \quad + \quad 117 \qquad\qquad 73$$
$$x \text{ gm.} \quad y \text{ gm.} \qquad\qquad 240 \text{ gm.}$$

$\frac{98}{x} = \frac{73}{240}$. $\qquad$ $\frac{117}{y} = \frac{73}{240}$.

$x = 322$ gm. H_2SO_4. $\qquad$ $y = 384.6$ gm. NaCl.

$322 \div 1.84 = 175$ c.c. H_2SO_4.

274. *From a Princeton Examination.*

How much carbon dioxide by weight and by volume, at 21° and 755

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mm., could be obtained by treating 8 grams of pure calcium carbonate with an excess of hydrochloric acid?

(Note.—A liter of carbon dioxide at 0° C. and 760 mm. weighs 1.977 g.)

Solution.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

$$\begin{array}{cc} 100 & 44 \\ 8 \text{ gm.} & x \text{ gm.} \end{array}$$

$$\frac{100}{8} = \frac{44}{x},$$

$$x = 3.52 \text{ gm. } CO_2.$$

$$3.52 \div 1.977 = 1.780 \text{ l. at } 0°, 760 \text{ m. m.}$$

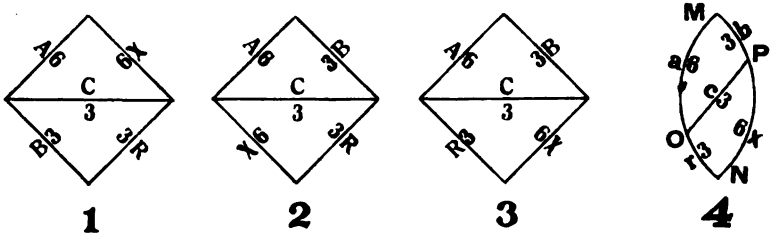
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}, \text{ or } \frac{760 \times 1.780}{273 + 0} = \frac{755x}{273 + 21}.$$

$$x = \frac{294 \times 760 \times 1.780}{273 \times 755} = 1.929 \text{ l.}$$

277. *Proposed by W. H. Magill, Westtown, Pa.*

In a Wheatstone bridge the A arm has a resistance of 6 ohms, the R arm 3 ohms, the B arm 3 ohms, the X arm 6 ohms, and the galvanometer is replaced by a resistance of 3 ohms. What is the total resistance between the battery binding posts of the bridge, and what current flows through the 3 ohms which replace the galvanometer when an E. M. F. of 9 volts is used?

Another solution and discussion by Wm. F. Rigge, Creighton University, Omaha, Neb.



The problem is vaguely worded. Which of the figures, 1, 2, or 3, here given, is meant, the battery wires in all cases being connected to the top and bottom? Is it No. 1, as the four solvers take it? If so, the sequence of the letters A, R, B, X is not observed, and the problem is too elementary for these pages. If it is No. 2, the sequence is again violated, and the solution given does not fit the case, because the resistances of the two circuits, AX and BR, are not equal. If it is No. 3, the sequence of the letters is most probably the one intended by the proposer, and the problem becomes worth the time a science teacher may devote to it.

Let us transform Figure 3 to 4, and use small letters to denote the volts in the branch circuits, the numbers being the ohms, and let us put large ones at the junction points, M and N being, as before, the battery terminals. As P is at a higher potential than O, a current will run through the coil C from P towards O. The total current is then equal to

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$$\frac{a}{6}+\frac{b}{3}=\frac{r}{3}+\frac{x}{6}=\frac{a}{6}+\frac{c}{3}+\frac{x}{6},$$

because the current in B is equal to the two in C and X, and therefore

$$\frac{b}{3}=\frac{c}{3}+\frac{x}{6}.$$

The partial currents are the one last mentioned, and

$$\frac{r}{3}=\frac{a}{6}+\frac{c}{3}.$$

We also have the voltages (9 being the total),

$$a+r=b+x=b+c+r=9.$$

Solving these equations we find the volts

$$a=x=\frac{36}{7},\quad b=r=\frac{27}{7},\quad c=\frac{9}{7},$$

and the amperes in A and X 6/7, in B and R 9/7, and in the coil C 3/7, and the total current = 15/7. The total resistance between the battery terminals M and N is then

$$9+\frac{15}{7}=\frac{21}{5}=4.2 \text{ ohms}.$$

Remarks by W. A. Tippie.

As to the Wheatstone bridge problem, Mr. Rigge has given a very interesting discussion of it. By changing the ordinary interpretation of the problem, he has made a real problem out of it, and has solved it. I shall be glad to see his discussion published in the *Science Question Department.*

281. *Submitted by Philo F. Hammond, University of Alberta, Edmonton South.*

The Editor suggests a careful comparison of the following examination paper with the College Entrance Examination Board paper published in October, 1917, SCHOOL SCIENCE AND MATHEMATICS.

Which is the easier? Which more nearly represents the attainment desired in pupils of high school age?

Is thinking in terms of mathematical relations (emphasized by the Board) more natural to the student of high school age than thinking in terms of verbal description (emphasized by Alberta)? Which is more desirable from a pedagogical point of view?

Are our efforts at teaching young students mathematical physics wisely expended?

Is it unpedagogical to teach physics in such a way that pupils will like it? Do they like mathematical physics?

A comparison of a College Board and Alberta physics examination by J. P. Drake, Emporia, Kan.

It is difficult to compare the two papers as to the amount of mathematics used, since one covers the entire field and the other is confined to magnetism and electricity and sound. Mechanics, heat, and light are more often treated mathematically.

Except for the above consideration the Board test is decidedly mathematical, and the Alberta test decidedly qualitative. The qualitative treatment appeals more to the student of high school age and experience than does the quantitative.

A better plan is to make the larger part of the work qualitative, but introduce enough of the mathematics to enable the student to grow in his ability to handle mathematical formulas and to see the value of a definite mathematical statement.

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IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

The 1917 meeting of the Iowa Association of Mathematics Teachers was held in Room 201, East Des Moines High School, Friday, November 2, at 2 p. m.

After the call to order by President F. K. Williamson, Chariton High School, an unusually strong program was presented.

The Publicity Committee report was given by the Chairman, Principal W. E. Beck, Iowa City High School. This committee distributes each year to the membership, copies of valuable reports and other publications of interest to teachers of mathematics. This year eight different reports and reprints were given out.

The first report of the committee on an "Iowa Syllabus of Secondary Mathematics" was presented in mimeographed copies, by the Chairman, W. S. Lines, Mason City High School. The other members of the committee are: Maria M. Roberts, Iowa State College, Ames; F. H. Stewart, North Des Moines High School; Helen M. Walker, Ottumwa High School; Lois Karr, Indianola High School. The report was adopted and the committee continued for further investigation.

The report on "Elimination of Subject Matter in Arithmetic," as given at the 1916 meeting of the Iowa State Teachers Association, was discussed by C. W. Wester, Iowa State Teachers College.

At this point in the program, the Iowa Section of the Mathematical Association of America, which was holding its meeting in an adjoining room, came in to hear the address by Professor W. W. Hart, University of Wisconsin, on "More Practical Matters As to Methods and Modes in Teaching Mathematics." This was an extremely practical, as well as an intensely interesting, presentation of this topic. The address was followed by questions and discussion.

The Nominating Committee reported the following officers for the coming year:

President—E. E. Watson, Parsons College, Fairfield, Iowa.

Vice-President—Maria M. Roberts, Iowa State College, Ames, Iowa.

Secretary-Treasurer (three-year term)—Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.

The report was adopted.

IRA S. CONDIT,
Secretary.

CONSERVATION OF COAL.

As a means of far-reaching economy the Government should at this time apply intelligent and direct-acting efforts to the conservation of fuel at the industrial plants which are responsible for its greatest consumption. It is unnecessary before a body of engineers to show proof that coal is wasted in vast quantities in the boiler furnaces of many plants, to feed which it is mined and distributed at a high and ever-increasing cost of labor and material.

The mining and distribution of coal has been placed under the supervision of a War Coal Board in order more nearly to meet the crying needs in these directions, and to apportion the coal in quantity and to uses deemed most expedient.

While this organized effort to bring about efficiency in the production and distribution of coal is being made, no parallel measures have been adopted to bring about a normal and practicable efficiency in its use. The hundreds of large plants which are consuming fuel wastefully are directly and needlessly causing a large fraction of the existing car shortage.

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They are overloading the already strained capacity of the railroads; they are rendering slower and more difficult the transportation of food and other vital commodities; and in short they are simply counteracting the measures of efficiency in production and distribution which have elsewhere been established.

Preventable Waste of Fuel.

The preventable waste of fuel in the boiler furnace of one steel mill amounted to 40,000 tons per year, which at $5 a ton would cost $200,000. This was a comparatively modern plant. The efficiency of boilers and furnaces in a fourteen-day test was fifty-five per cent. The load factor was unusually favorable to high efficiency and could readily be raised to seventy per cent or over. This is only one example, and there are many more extreme cases.

The saving or wasting of one-fourth of the coal consumption of any industrial plant depends entirely upon the efficiency of its operating management. This fraction of the consumption relates exclusively to the boiler plants, i. e., the production of steam, and does not include the large economies possible in connection with its distribution and use.

Under present conditions a plant which carelessly operates at an efficiency of forty to fifty per cent receives from the Government the same consideration in the delivery of coal as the one whose efficiency is seventy to seventy-five per cent. This obviously is unfair as well as wasteful.

The Government hands over, say, 200,000 tons of coal a year to a plant owner, but asks for no account as regards its consumption, nor any questions as to the amount of steam it is made to produce. There is, nevertheless, an equivalent amount of steam this fuel is capable of generating, and it can and should be made to produce that quantity.

In general, there are two plans of operation worthy at least of consideration. One might be termed the autocratic method. This would involve the use of authority to compel coal consumers to execute such measures of economy as the proper authorities might prescribe for any given case. Limits to be set as to expense to the user. Such limits might be in terms of a percentage of their present yearly coal bill. Alterations to be directed chiefly, as previously implied, to purely operating improvements. Many objections would probably be made by consumers against this plan, but once in effect the majority would no doubt realize its pecuniary advantage to themselves. But its tendency may be too strongly opposed to democratic principles.

The other plan would be largely an educational one, in which patriotism and efficiency would furnish the motive forces required.

The teaching must be accomplished with the utmost simplicity and directness. Above all it must be in such form as to be readily comprehended and applied.

The U. S. Bureau of Mines has for a number of years engaged in obtaining and disseminating scientific information regarding the mining and consumption of coal, and the results of the work have been of great value to technical engineers who are able to use and apply it. It is evident that we now require an extension of the idea of education, but in such form as directly to affect the men who run the boiler plants of our country, for in their hands is the saving or wasting of one-fourth of our fuel supply.

Six hundred million tons of coal were mined in the United States in 1916. If we assume only one-half of this to have been used for our industrial boiler plants, then a quarter of the coal used under boilers amounts to 75,000,000 tons per year. It is worth while to save this fuel by preventing its waste. This quantity of coal represents the use of 1,500,000 fifty-ton freight cars.

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GENERAL MINUTES OF THE 1917 MEETING OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The seventeenth annual meeting of the Central Association of Science and Mathematics Teachers was held at the University of Ohio, Columbus, Ohio, November 30 and December 1, 1917. A fine spirit of hospitality was manifest throughout the whole convention and the splendid facilities and complete arrangements for the comfort and convenience of the members were evidences of the labor and forethought of the local committee.

Friday morning the delegates were cordially welcomed to the city by Hon. George J. Karb, mayor of Columbus. Professor Charles H. Smith of Hyde Park High School ably responded for the Association. The main addresses of the morning were given by Dr. William Oxley Thompson, President of Ohio State University, on "Immediate and Ultimate Aims of Science and Mathematics Teaching" and Dr. L. H. Bailey of Cornell University on "Science Element in Education." These addresses are printed in full in the Proceedings.

Friday afternoon was devoted to Section programs, inspection of exhibits, and an informal reception in the University library. At the preliminary meeting Friday evening, Vice-President Harry D. Abells presided and the reports of the members of the Committee on "Science in the High School of Tomorrow" were presented. Mr. B. J. Rivett of Detroit, Mich., discussed the subject in its relation to Physics, and Miss F. B. Hunter of the University of Chicago in its relation to Home Economics. In the absence of Mr. H. B. Shinn of Chicago, Miss Nellie M. Cook of Springfield, Ill., read his report on "Biology in the High School of Tomorrow"; in the absence of Mr. H. N. Goddard of Madison, Wis., Mr. F. T. Jones read his paper on "Nature Study in the Seventh, Eighth, and Ninth Grades." Mr. W. R. McConnell of Platteville, Wis., read a paper from Mr. J. H. Smith of Chicago on "The Necessity of Geography in the High School." Chairman Franklin F. Jones briefly summarized the work of the committee and presented charts showing the possible arrangement of science courses from the seventh to the twelfth grades. It was moved and carried that the committee be continued for one year, and two additional members were added to the committee.

The lecture of the evening was given by Dr. Robert F. Griggs of Ohio State University, on "Katmai and the Ten Thousand Smokes." Dr. Griggs has recently returned from Alaska where he made explorations under the auspices of the National Geographical Society. It is unfortunate that copyrights owned by this society make it impossible for the Association to publish this interesting number in full.

Saturday morning was given over to routine business. The minutes of the 1916 meeting were read and approved. The Auditing Committee reported that the Treasurer's books were correct. The Treasurer's report was read and accepted. In the absence of Mr. E. L. Mahaffey, the Treasurer read the report of the Membership Committee and the list of new members to be voted in. Sixty-five new members were added to the Association. The following committees also presented reports: Necrology, Advertising, and Railroad and Steamship Maps. In the absence of Mr. H. L. Terry of Madison, Wis., Mr. H. R. Smith of Chicago read the report of the Committee on Resolutions, which follows:

"Realizing the tremendous significance of the principles involved in the present world conflict, the Central Association of Science and Mathematics Teachers in convention assembled at Columbus, Ohio, November 30 and December 1, 1917, publish the following resolutions:

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"Resolved:

"I. That we affirm our trust and confidence in the wisdom and management of America's entry into and service in the present war.

"II. That we heartily support President Wilson and all the branches of the Government in the successful prosecution of the war.

"III. That we, as teachers, are not content to 'do our bit' but we will *do our utmost* in advancing efficient education.

"IV. That it is imperative that we, as teachers, look ahead and consider what our present pupils must do when they take up life work in the reconstruction period after the war.

"V. That we urge our membership and all teachers to beware of false economy in limiting growth in the ideals and inspirations of teaching.

"Be it further Resolved: That we mark with sorrow and regret the demise of a former honored President, James F. Millis, and that we will cherish his memory by increased devotion to the cause of progressive education, of which he was a most faithful exponent.

"Be it further Resolved: That we acknowledge our appreciation of the cordial welcome given by the city of Columbus, through Mayor George J. Karb and by the University of Ohio, and through President William Oxley Thompson.

"That we offer our sincere thanks of appreciation to the speakers of the General Session, President Thompson, Dr. Bailey, and Dr. Griggs, for their inspiring addresses.

"That we also thank all others who have contributed to our comfort and entertainment, Mr. and Mrs. George Arp at the reception, the newspapers of Columbus for their publication of the Association meetings.

"That we commend the activity of the Committee on the High School of Tomorrow and recommend that it continue its work in the light of changing content and methods in education.

"The committee begs to submit the following suggestions as a general theme for the year 1918: 'The educational demands of an awakened democracy.' "

H. R. SMITH,
C. E. COMSTOCK,
MISS JESSIE CAPLIN,
Committee.

The Nominating Committee reported the following:

President—Harry D. Abells, Morgan Park Academy, Morgan Park, Ill.

Vice-President—William M. Butler, Yeatman High School, St. Louis, Mo.

Treasurer—John H. McClellan, Harrison Technical High School, Chicago.

Assistant Secretary—D. A. Lehman, Goshen College, Goshen, Ind.

Assistant Treasurer—M. F. Wadleigh, South Division High School, Milwaukee, Wis.

HERBERT E. COBB,
Chairman.

It was moved and carried that the Secretary be instructed to cast the ballot of the Association for the officers named and they were declared duly elected.

Invitations from Cincinnati and Chicago for the 1918 meeting were read and the matter was referred to the Executive Committee.

A. W. CAVANAUGH,
Secretary.

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TREASURER'S REPORT OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS FOR THE YEAR ENDING NOVEMBER 30, 1917.

Receipts.

Balance at previous report		$ 480.95
Five copies Proceedings		2.50
Advertisements in 1916 Program		265.00
Advertisements in 1917 Program		24.00
Membership dues at $2.50	$1,920.00	
Membership dues, irregular	119.15	
Total membership dues		2,039.15
Total receipts		$2,811.60

Expenditures.

Subscriptions to School Science and Mathematics		$1,107.25
Subscriptions to American Journal of Home Economics		108.50
Proceedings, 1916, printing and distributing		427.64
Program, 1916, printing and distributing		275.02
Rebates to local centers		4.00
Miscellaneous:		
Biology Section, expense	$ 8.00	
Earth Science Section, expense	7.32	
Home Economics Section, expense	2.10	
Mathematics Section, expense	15.00	
Chemistry Section, expense	4.81	
Physics Section, expense	3.85	
Convention speakers	70.30	
President's expense	21.57	
Membership Committee, expense	181.88	
Secretary's expense	10.77	
Treasurer's expense	62.50	
Treasurer's salary 1915-16	25.00	
Treasurer's bond	2.50	
Advertising Committee, expense	10.50	
Printing and stationery	47.93	
Excursion	4.50	478.53
Balance		410.66
		$2,811.60

Membership Report for the Year Ending November 30, 1917.

Paid-up membership, December 1, 1916		973
Honorary membership		9
Total membership		982
Delinquent, but left on the list as per Constitution		88
Total names remaining on the list, November 30, 1917		1,070
New names added during the year		214
Total		1,284
Resigned during the year	132	
Deceased or dropped for delinquency	65	197
Net Constitutional membership, November 30, 1917		1,087
Paid-up membership, November 30, 1917		990

JOHN H. MCCLELLAN,
Treasurer.

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MINUTES OF BIOLOGY SECTION, CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

On Friday, November 30, at 1:30 p. m., in Room 100 of the Biology Building of Ohio State University, the joint meeting of the Biology, Agriculture and General Science Sections was called to order by the chairman, Miss Nettie M. Cook, Springfield, Ill. In the absence of Mr. Jerome Isenbarger, Secretary of the Biology Section, the chairman appointed Miss Estelle Feldmann, Columbus, Ohio, as Secretary pro tem. The following three members were proposed to the chairman to serve on the Nominating Committee: Miss Francis Reinhard, Columbus, Ohio; Miss Nettie M. Cook, Springfield, Ill.; Miss Mary Goodard, Ypsilanti, Mich.

The chairman announced that the topics of the following program were those generally suggested as a result of the questionnaires that had been sent to all the members. Since these papers are given in the Proceedings, no abstracts of them are included in these minutes: L. J. Cole, University of Wisconsin, Madison, Wis., gave an illustrated lecture on "Plant and Animal Breeding in Relation to Biology Teaching in High School." E. N. Transeau, Ohio State University, Columbus, Ohio, read a paper on "The Rise of Sap in Trees." M. M. Wells, University of Chicago, Chicago, Ill., read a paper on "The Relation of Ecology to High School Biology."

The meeting adjourned until Saturday, December 1, at 10:00 a. m.

The Saturday morning meeting was called to order by the chairman.

Since the Executive Committee of the Agriculture and General Science Section was not present, Miss Spielmeyer of Cincinnati, Ohio, made a motion to have a joint meeting of the Biology, Agriculture and General Science Sections again. This was seconded by Miss L. Marzetti, Columbus, Ohio.

The Nominating Committee presented the following report: Chairman, Mr. Jerome Isenbarger, Nicholas Senn High School, Chicago, Ill.; Vice-Chairman, Miss Rousseau McClellan, Shortridge High School, Indianapolis, Ind.; Secretary, Mr. C. H. Sackett, Ben Blewett Junior High School, St. Louis, Mo.

The chairman turned the meeting over to G. R. La Rue, University of Michigan, Ann Arbor, Mich., leader of the Round Table. Mr. La Rue stated that he was interested in the problems confronting teachers and how they were solving them, as students were receiving part of their biological training in his department before entering on their teaching career. The program follows: "Note Books," C. H. Sackett, St. Louis, Mo. "School and Home Gardens with High School Botany," Miss Rousseau McClellan, Indianapolis, Ind. "Do College Courses as Now Administered Fit for Botany Teaching in High School?" Miss Mary A. Goodard, Ypsilanti, Mich. "The Present Status of General Science as to Content and Method," Mr. F. D. Barber, Normal, Ill.

Next was to have followed a paper by E. M. Gilbert, Madison, Wis., but since Mr. Gilbert did not agree with many statements made by Mr. Barber, he asked that the time allotted him for the reading of his paper be given to the discussion of these statements.

Discussion of the papers was next on the program.

Miss M. Flynn, Columbus, Ohio, objected to Mr. Sackett's statement, "by all means have the laboratory problem inked." She contended that a medium hard pencil served the same purpose and also saved time. Miss Cook, Springfield, Ill., thought it is not necessary to ink, as the laboratory problem was collected at the end of a period, put on file and de-

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stroyed at the end of a semester. It was found necessary to do this in order to avoid copying. Miss Flynn thought the student should be allowed his laboratory problems at the end of the semester, as he very often used his laboratory book as a reference book. She had found this to be especially true of Normal girls. Mr. C. Recker, Columbus, Ohio, remarked that biology was not so stereotype a subject that different problems could not be used from year to year. Mr. La Rue, Ann Arbor, Mich., stated that very often the University required the laboratory book of a student, especially when they had no knowledge of the kind of science work being taught in the high school from which the student came.

Miss Speilmeyer, Cincinnati, Ohio, asked Miss McClellan if material was supplied to the children for their school gardens, or if the children raised their own early plants. Miss McClellan said that the teachers had friends and certain people who raised plants by thousands in frames and these were distributed to the children at a very cheap rate. Very little was given them. The chairman stated that this general enthusiasm for gardening throughout the country was not only for emergency but for the future. That the biologist of today does not know enough about practical gardening. This general movement towards home and school gardening was of great value to the child, as it gave him an opportunity to become acquainted with living things. That there are quite a few biological facts which a child of twelve years ought to know. He then told about a city boy taking a biological study at college making a statement that he had never seen a toad, and that it was the height of his ambition to go on a field trip and catch one. Such people, said the chairman, were very hard to handle in high school as well as college.

The chairman asked for some experiences of those who made field trips an integral part of their biology course.

Mr. Sackett, St. Louis, said that he usually conducts such trips on Saturdays. That they are purely voluntary. That the trips are carefully planned and that the pupils know just what to look for. Besides enriching their biological knowledge, it gives them a wealth of material which they use in their English.

Miss McClellan said that six to eight weeks were devoted to the study of insects and therefore she conducts three field trips in the fall. On these trips the pupils are taught to catch and collect insects. In the spring she takes up bird study. For this she finds evenings and early mornings, say 4 a. m., very good. As a result of these trips, pupils come to know 75 to 100 birds.

Miss Flynn, Columbus, Ohio, said that the science teachers of Columbus are permitted to take each class one afternoon a term on a field trip. That her classes always have their outlines ready and take notes in the field.

Since Mr. Gilbert had not agreed with Mr. Barber's statement that botany and zoology are losing out and within a few years will no longer appear on the course of study, the meeting was turned over to him.

Mr. Gilbert, Madison, Wis., said that as a matter of fact the colleges are up against it. English is the only study required. The pupil in selecting his course is not supposed to be advised. It is therefore in his Junior year that he sees the need of a biological study and then many inconveniences arise. Thus it is left entirely to outside forces to encourage the student in taking up a biological course.

Mr. Wells, Chicago, Ill., said that supposing the names of botany and zoology should be lost to the high schools, people nevertheless are not losing their interest in biological phenomenon but are studying botany and zoology under another system and name.

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Mr. Gilbert said that botany has gained in Wisconsin. Schools that have never taught it before now teach it a half year.

Mr. La Rue remarked that the difficulty in Michigan has been that teachers have not been qualified to teach these subjects. Another reason is that colleges have not prepared the student to teach botany and zoology. It has offered an old stereotyped course, such as studying the hydra instead of some local animal, and does not solve at all any of the problems which a teacher would be apt to need in teaching biology. At present the University of Michigan is trying to make a course which will in time meet the demands of the biology teacher.

Mr. Wells, Chicago, Ill., said that he did not think that the lack of preparation and poor teaching on the part of the biology teacher forced the agriculture and domestic science teacher to teach biology because, as a fact, the poorest teaching was found among these.

Mr. Barber stated that he based his facts on those given him by the State School Commissioner of Wisconsin, and he ought to know.

Miss Cook, Springfield, Ill., said that general science increased the enrollment in zoology and botany in their schools.

Upon motion duly made and seconded, the meeting was declared adjourned by the chairman.

ESTELLE FELDMANN,
Secretary pro tem.

MINUTES OF THE CHEMISTRY SECTION, CENTRAL ASSOCIATION SCIENCE AND MATHEMATICS TEACHERS.

The Chemistry Section was called to order by Chairman Powers at 1:30 p. m.

In the absence of Secretary Ladd of Gary, Ind., Mr. A. C. D. Metzger of Columbus was chosen in his stead.

The chair appointed the following committees:

Nomination—Mr. Heilman, Mr. Weaver, Mr. Sharp.

Resolutions—Mr. McCarty, Mr. Abells, Mr. Collins.

Critics—Mr. Osborne, Mr. Smith, Mr. Williamson.

As there was no further business, the program as published was presented:

Prof. D. J. Demarest, Professor of Metallurgy, Ohio State University, read a splendid paper on "Special Applications of Chemistry in Shell-Steel Manufacture." After a few questions and a very brief discussion by Mr. Sharp, Chairman Powers, Mr. Gullum and others, the next paper was called:

"Laboratory Notes in High School Chemistry," by Mr. C. J. Pieper, University High School, University of Chicago. As Mr. Pieper was not present, his paper was read by Mr. Gullum of Columbus.

The discussion was led by Charles M. Sharp, Shortridge High School, Indianapolis. He said among many other things that he had not read the paper beforehand and would thus present some of his own views rather than a discussion of Mr. Pieper's paper. The objective points in High School Chemistry are: 1. Feeling for the work; 2. To think logically; 3. To view clearly the thing in hand; 4. To accomplish something; 5. To reason out a conclusion; 6. To state definitely a problem; 7. (and most important of all) to show observations and state the conclusions correctly. The student should be able to state the proper conclusion when tabulating his data. The problem in notebook work is to give the student some definite or specific thing to do, not give a general problem like making oxygen, etc.

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Further discussion by Mr. Smith: Also by Mr. Stouffer and Mr. Osborne:

Mr. Jones of Cleveland told of his method of grading, using large sheet of bristol board for checking up the pupils, so that both he and the pupil would always know whether the work were kept up or behind.

He also stated that no pupil could get an A if his work was late or there was even a misspelled word in his book. Several members stated that Mr. Jones was too rigorous in his grading and that by so doing he would often lose the most essential thing in the notebook work—a feeling for the subject instead of English only.

Dr. McFarland at this point complimented the many good things that were stated in the paper and expressed his appreciation of what many high schools are doing in the concrete way of engendering a feeling for the work and a genuine scientific spirit in the chemistry pupils. He showed from his experience some of the following things: Examining and dealing with: (a) Theses for degrees; (b) Managers of industrial plants; (c) Chemical problems.

In (a): (1) They do not state definitely their problems; (2) Do not get accurate records of their experimental work; (3) Fail to pick up essentials and reject the nonessentials; (4) Not able to combine the data and get practical conclusions. All this is important in the commercial world as in the laboratory.

In (b), standpoint of managers: (1) Lack of ability to make an accurate report; (2) Do not keep proper records so that they can make a clear, concise report.

In (c), problem courses: (1) Not able to choose the proper literature bearing on the problem; (2) Fail to use proper design and methods of recording and explaining the work. Here the student must work out his own data. He has no data given; (3) Here, again, he often fails to make out a satisfactory, clear, logical report. This is *most important*, and nowhere can a student get the habit of doing this as well as in the high school, when he is in the formative period of adolescence.

After a few remarks by the Chairman, Miss Jessie Caplin, West High School, Minneapolis, Minn., presented "The Chemistry Show," which displayed among many other things the following:

1. A small Liebig's condenser.
2. Hot water heater.
3. Some books: Modern Science Reader, Book of Fiction WO_3, etc.
4. Pyrometer cones from pottery.
5. Pyro lighter.
6. Sulphur ore.
7. Sulphur cones in test tube.
8. Sulphur crystals, rhombic, etc.
9. Lead buckles.
10. Color photography.
11. Heavy iron screen.
12. Burning of Mg to show oxidation.
13. Paper-made burlap, ropes, etc.
14. Logarithms use in laboratory.
14_1. Jena glass, specimens, both good and bad.
15. Use of dental gold instead of gold leaf.
16. Coal tar model.
17. Asbestos.

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18. China, good and bad.
19. Mohair, wool, cotton, etc.
20. Many pictures, etc.
21. Hydrogen generator, etc.

Miss Caplin's illustrations and experiments were well received and she was asked to have her show again next year.

Mr. Sharp showed:

1. Presolyte CO_2 cylinders.
2. Hoskin's alloys of alumel and cromel.

Mr. Jones spoke of his making liquid chlorine in field.

Meeting adjourned till next day.

Chemistry Section, Saturday, 9:30 a. m.

Chairman Powers called for reports of committees:

The Nomination Committee reported the following officers selected:

Chairman—F. B. Gullum, East High School, Columbus, Ohio.

Vice-Chairman—Raymond W. Osborne, Parker High School, Chicago, Ill.

Secretary—Miss Jessie Caplin, West High School, Minneapolis, Minn.

The above were declared elected.

Mr. Osborne showed some samples of conservation of fats made into soaps by his pupils.

At this time Mr. Heilman and Mr. Mahaffey explained the field trips, time for starting, etc.

As there were no members of the other committees ready to report, the program was taken up as per schedule:

Mr. Rivet read a paper on "The Place and Importance of Chemistry in the High School Course"—

Mr. Smith read a paper on "A Simple Method of Presenting the Atomic Theory."

In the absence of Dr. Bell, his paper was read by Mr. Powers. Subject, "A Study of the Attainments of High School Pupils in First Year Chemistry."

Dr. McFarland read a splendid paper on "The Work of the Amercian Industrial Chemist in War Time."

A brief discussion of Dr. McFarland's paper was participated in by Mr. Twiss in which he commended the paper and stated that teachers should show to their pupils (boys especially) the true and real value of chemistry, and give advice, i. e., vocational guidance, which is so much talked of nowadays.

Mr. Jones stated that they should be taught that the study of chemistry throws a strong light on industry. But not all are fitted to become chemists. Chemists are few. A boy must have chemical imagination plus a willingness to do good hard work.

After a few further remarks by Messrs. Smith, Abells, Dr. McFarland, et al., the remarks led to Dr. Bell's paper.

Mr. Jones spoke of the weakness of Dr. Bell's list of test questions. Mr. Osborne likewise criticized Dr. Bell's paper and suggested that it was not the sense of this body to accept his conclusions as anywhere near fina'.

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As the hour was late, the meeting simply drifted apart without any formal adjournment.

Respectfully submitted,

A. C. D. METZGER,
Secretary pro tem.

MINUTES OF THE PHYSICS SECTION, CENTRAL ASSOCIATION SCIENCE AND MATHEMATICS TEACHERS.

Friday, November 31. The meeting was called to order by the temporary chairman, Mr. Charles T. Prose, of the Zanesville, Ohio, High School. Papers were presented by Mr. H. H. Reighley of the East Columbus High School, Prof. F. C. Caldwell of the Ohio State University, and Prof. J. A. Culler of Miami University. After a discussion of the papers, the following Nominating Committee was appointed by the chairman: Prof. F. D. Barber of Normal University, Normal, Ill.; R. H. Struble, Eastern High School, Detroit; Prof. George R. Twiss of the Ohio State University. Following adjournment the section visited the electrical engineering laboratories of the State University under the guidance of Prof. Caldwell.

Saturday, December 1. The meeting was called to order by the temporary chairman, Prof. J. A. Culler, of Miami University. Papers were given by R. O. Austin, formerly of the High School of Commerce, Columbus, Ohio, and by Franklin T. Jones, of the University School, Cleveland, Ohio. The remainder of the forenoon was given up to a discussion of these papers. The Nominating Committee presented the following names for the officers of the section for 1918:

Chairman—W. R. Aherns, Englewood High School, Chicago.

Vice-Chairman—Prof. F. R. Gorton, State Normal School, Ypsilanti, Mich.

Secretary—Clyde H. Krenerick, North Division High School, Milwaukee, Wis.

These were unanimously elected. During the afternoon the members of the section visited the city water works and filtration plant.

A. BJORKLAND,
Secretary pro tem.

THE ALBERT TEACHERS' AGENCY.

The Albert Teachers' Agency of Chicago, which for the past fifteen years has been doing business at 623 S. Wabash Avenue, has moved its quarters to the New Kimball Building, 25 E. Jackson Boulevard. The constant increase in the business of the Agency has made this removal necessary. The Agency's new pamphlet, *Teaching As a Business*, contains interesting chapters on salaries as affected by the war, and much information of value to teachers and others engaged in educational work. Sent free to any address.

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Physostegia Virginica is usually called false dragonhead or lion's-heart in the books, but the knowing ones call it obedient plant because of the curious habit the flowers have of keeping any position in which they may be placed. Turned either to the right or left, they do not spring back when released as other flowers do. The structure of the pedicel which makes such changes possible appears never to have been studied nor, so far as we know, has any attempt been made to discover what use this peculiar faculty is to the plant. Happening recently to pass numerous clumps of this plant on a windy day, we observed that all the flowers were turned away from the wind and remained in this position during lulls in the breeze. We are disposed to suggest, therefore, until a better explanation is forthcoming, that the yielding of the flower stalks to pressure of any kind serves to protect the essential organs by turning the opening of the flower away from danger.—[*American Botanist.*

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BOOKS RECEIVED.

Radio Communication. Theory and Methods. With an Appendix on Transmission over Wires, by John Mills, Western Electric Company. Pages xi+205. 12.5×18.5 cm. Cloth. 1917. $1.75 net. McGraw-Hill Book Company, New York City.

Religious Education and American Democracy, by Walter Scott Athearn, Boston University. Pages xi+394. 13.5×19 cm. Cloth. 1917. $1.50. Pilgrim Press, Boston.

Plane Geometry, by Claude I. Palmer, Armour Institute, Chicago, and Daniel P. Taylor, High School, Oak Park, Ill., edited by George W. Myers, School of Education, University of Chicago. Pages v+277. 13.5×20 cm. Cloth. 1915. $1.00. Scott Forsman & Company, Chicago.

The Botany of Crop Plants, by Wilfred W. Robbins, Colorado Agricultural College. Pages xix+681. 14×20 cm. Cloth. 1917. $2.00. P. Blakiston's Son & Co., Philadelphia.

College Algebra, by Ernest B. Skinner, University of Wisconsin. Pages vii+263. 13×19 cm. Cloth. 1917. $1.50. The Macmillan Company, New York City.

Education for the Needs of Life, by Irving E. Miller. Pages vii+353. 13×19 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

The Natural History of Chautauqua, by Vaughan MacCaughey of the Chautauqua Summer School. 135 pages. 14×21 cm. Cloth. 1917. B. W. Huebsch, Publisher, New York City.

General Zoology, by A. S. Pearse, University of Wisconsin. Pages vii+366. 15×22 cm. Cloth. 1917. Henry Holt and Company, New York City.

Mathematics for Collegiate Students of Agriculture and General Science, by Alfred M. Kenyon and William V. Lovitt, Purdue University. Pages vii+357. 13×19 cm. Cloth. 1917. $2.00 The Macmillan Co., New York City.

An Elementary Study of Chemistry, by William McPherson and William E. Henderson, Ohio State University. Pages xii+576. 14×19 cm. Cloth. 1917. $1.60. Ginn and Company, Boston.

Science for Beginners, by Delos Fall, Albion College. Pages ix+382. Cloth. 1917. World Book Company, Yonkers-on-Hudson, New York.

Logarithms and Anti-logarithms, by C. H. Forsyth, University of Michigan. 46 pages. 15.5×23.5 cm. Cloth. 1917. 75 cents. George Wahr, Ann Arbor, Mich.

Exercise and Review Book in Biology, by J. G. Blaisdell, High School, Yonkers, New York. Pages viii+152. 20×26 cm. Paper. 1917. 80 cents. World Book Company, Yonkers-on-Hudson, New York.

BOOK REVIEWS.

A Textbook in the Principles of Science Teaching, by George R. Twiss, High School Inspector of the State of Ohio. Pages xxvi+486. 14×20.5 cm. Cloth. 1917. $1.40. The Macmillan Company, New York City.

This splendid book is primarily for teachers who are in the service and as a textbook for the use of instructors who are giving courses to people in the theory of teaching. It is written by a person who is abundantly able to write upon matters of this kind, out of the rich fund that he has been collecting for many years in his high school work and in his contact with secondary school teachers. The book shows splendidly, in a practical and at the same time concrete way, how the recent developments in

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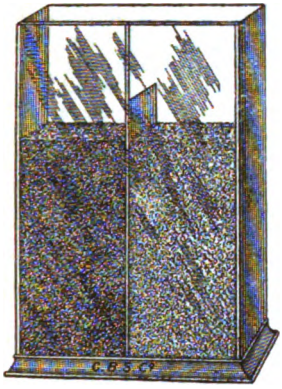

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experimental and educational psychology may be applied in science teaching. The volume will be exceptionally helpful to a large mass of science teachers of the older brand, at least, who have not seen fit to give the psychology of science teaching very much of a hearing in their professional work. If this class of teachers will carefully study the book they surely will find many suggestions which will enable them to teach more efficiently than they have been doing. Indeed, the text is a real handbook for any science teacher. It will help him over many difficult places. In schools of education this book may well be used where courses are given in the various sciences of which the book treats. In fact, it is a text that any person who is in any way connected with science teaching in secondary schools or schools of education cannot help but profit by studying.

There are twenty-four chapters under the heads of The Meaning of Science, The View Point for the Science Teacher, the Genesis of Science, Science and Children, Methods of Teaching, Educational Functions and Value of the Sciences, The Disciplinary and Cultural Values of Science, Classroom and Laboratory Instruction, Lectures, Examinations and Reviews, Equipment for Science Teaching, The Sciences and the Curriculum, Biology, Biological Equipment, Geography, Fundamental Principles of Geography, Methods in Geography, Geographical Equipment, Physics, Methods in Physics, Equipment for Physics Teaching, Chemistry—Principles and Methods, Chemistry—Practical Suggestions, Chemical Equipment, General Science Courses, and Examinations and Tests.

The diction is clear and the style simple. It is interesting reading for any science teacher. The book is printed in 10 point type on uncalendered paper. The major paragraphs have the key of the matter in each paragraph in a few words at the beginning in bold faced type. Each chapter closes with questions for further study, together with a bibliography of the matter treated in that chapter. There is a splendid appendix devoted to a list of science books for a high school library. A very complete index is appended.

It is a book that no science teacher should be without.

C. H. S.

How to Make High Pressure Transformers, by F. E. Austin, Hanover, New Hampshire. 46 pages. 11.5×18 cm. Paper. 1917. 65 cents. Published by the author.

How to Make Low Pressure Transformers, by F. E. Austin, Hanover, New Hampshire. 22 pages. 11.5×18 cm. 1916. 40 cents. Paper. Published by the author.

These are two of the most helpful little books on this subject which the writer has had the pleasure of reading and examining. Instructors in electrical engineering and constructive work in advanced physics cannot do better than to use these little books as texts and outlines for the construction of high and low pressure transformers. Any person who has a fair knowledge of transformers can use the books without assistance other than the illustrations contained in the texts. C. H. S.

Stony Island—A Plea for Its Conservation, by Zonia Baber, School of Education, University of Chicago. 16 pages. 15×23 cm. Paper. 1917. University of Chicago Press.

This little pamphlet is a wonderful and eloquent plea for the preservation of that tract of territory in the southeastern part of the city of Chicago between 91st and 94th Streets and extending from Stony Island Avenue eastward to Kingston Avenue. There are comparatively few people in the great city of Chicago who are aware of the existence of a

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rock outcrop such as is this Stony Island. For its educational value to the high school pupils of the city it should be preserved. In fact the city of Chicago ought to purchase this tract of land and hold it as a park where students and others may go and study the geological formation, as well as the unique vegetation there displayed. C. H. S.

Examples in Magnetism, by F. E. Austin, Hanover, New Hampshire. 90 pages. 12.5×19 cm. Paper. 1916. $1.10. Published by the author.

This little book tells one who has a knowledge of trigonometry and who is beginning the study of that subtle force, magnetism, of some of the things that he must master and do if he is to be successful in this phase of science work. The book will act as a splendid guide to those students who are beginning the study of electrical engineering. There are twenty-seven drawings and halftones given. The method of procedure is to give a particular example of the matter in question, with an explanation of it, after which the real problem bearing on the example is given. There are several tables appended which have direct use in the study of the book. The book is well worth the price, and every student in electrical engineering should possess a copy. C. H. S.

Examples in Battery Engineering, by F. E. Austin, Hanover, N. H. 90 pages. 12.5×9.5 cm. Cloth. 1917. $1.25. Published by the author.

A very complete and comprehensive discussion of the practical use of primary and storage cells, together with the theory and the mathematics of the same. Special stress is placed upon storage cells, which is a very valuable feature of the book. There are many things of an elementary nature in the book, and the more difficult part of it, under the Theory of the Storage Cell, can readily be mastered by anyone interested in cell work. As is customary with this author, he presents an example on a certain question which he wishes to discuss. This is followed by the solution and the discussion, after which a concrete example of a similar nature is presented. A bibliography is appended. The book should be in the hands of all students who are studying primary or storage cells. C. H. S.

Radio Communication. Theory and Methods. With an Appendix on Transmission over Wires, by John Mills, Western Electric Company. Pages xi+205. 12.5×18.5 cm. Cloth. 1917. $1.75 net. McGraw-Hill Book Company, New York City.

This book is really the gist of a course of lectures which were given by Mr. Mills in the summer of 1917 to a company of the United States Reserve Signal Corps troops. No one is better qualified to talk or write on this subject than the author of this text, and the matter presented in the book is authoritative in every respect. One without some training in radio work would be unable to handle the book alone, but when used as a textbook by a competent instructor it becomes clear and helpful to any student. The recent rapid development of radio activity and radio apparatus has been so marvelous that one is obliged to be on the alert continually if he is going to keep up to date with the progress of radiography. The present war has been an incentive to all people interested in this subject to improve on the apparatus and everything else of a mechanical nature used in the transmission of radiograms. Young men who are now enlisting in this phase of governmental work should possess copies of this book, and they no doubt will be brought in touch with competent Government instructors who will be able to lead them through the book, thus securing a knowledge of radiography which will stand them in good stead in the positions in which the Government will station them.

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MARCH, 1918

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

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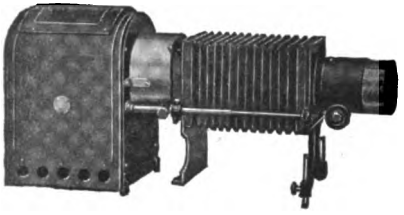

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 3 MARCH, 1918 WHOLE No. 149

TEACHING HIGH SCHOOL PUPILS THE INSECTS.[1]

By JEROME ISENBARGER,
Senn High School, Chicago, Ill.

The statement needs no amplification that to arrive at any results which are worth while in the teaching of the subject of insects in the high school, the teacher must have well-defined aims which he expects to follow out. It is true also that in the last two decades high school zoology teaching has undergone a distinct metamorphosis if we are to judge by comparing the latest texts with the older ones. Considering the question as to whether the difference in the texts is accounted for by a change in aims or a change in method, I am inclined to think that the subject matter of our modern courses has been selected with a view to accomplishing purposes which were not thought of in connection with some of the earlier courses.

In addition to the magic transformations, exceptional beauty, examples of superior instinct and intelligence, and other interests, we have the relation of insects to man and other animals which gives the subject a solid, practical basis which is universal in its appeal.

According to Sanderson (1912), a conservative estimate of the tax imposed upon the people of the country by insects puts it at more than a billion dollars, and this does not include the havoc wrought by the typhoid fly, which probably amounts in loss to the people in money alone to another billion of dollars. Who pays the tax? The farmer who is more directly concerned receives a shorter crop, but he gets higher prices for the produce he has to sell, due to the depredations of insects. So, after all, the common people pay the price of ignorance. So the solution of the insect problem concerns each person whether living in the city or on the farm. Information on the subject needs to be generally disseminated in order that we may not have the igno-

[1] Read at the High School Conference, University of Illinois, Urbana, Nov. 23, 1917.

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rant person who will breed insect pests to the detriment of a whole community or who will interfere with the problem by killing, either directly or indirectly, the song birds and other insectivorous animals, by harboring uncontrolled cats which destroy on the average, according to Forbush, fifty song birds a year.

The principal purposes to be achieved in the study of insects should be, (1) to awaken in the pupil an abiding interest in insect life, (2) to help the pupil to realize that the problem of insect control is one of interest to all persons whether living in the city or on the farm and that all persons should have some knowledge of insect structure, instinct, and metamorphosis in order that the problem can be intelligently dealt with, (3) to teach the pupils biological principles with the insects as examples, (4) to give training in original thought and accurate observation from a study of the living insect.

The selection of types for the work should depend upon the locality and the practical interests of the pupils. The insects chosen for use in a farming district should be, as far as possible, those which affect the farm crops of the region or in some other way touch the life of the boys and girls. The selection of forms for study in the city should be such as to convince the pupil that he is face to face with the insect problem and should have a part in its solution.

In any case the choice should be made so that at least one stage in the life of the insect can be studied from the living form and it will be better still if the whole life history can be studied in the laboratory or in the field from the living specimens. It is much more important that we are able to study the living animal than any attempt at following the phylogenetic sequence which substitutes preserved material for the living specimens.

The first form studied in the Senn High School at the beginning of the fall semester is the caterpillar of the Cecropia or of the Polyphemus moth. As a matter of fact we always have both. The reasons for introducing the work with these forms are as follows: (1) They are large in size and the external features are simple. (2) They are easily found along with their pupae during the early part of September. (3) They are occasionally found as pests on shade trees and shrubbery, and hence are of some economic importance to city people.

For individual study, each pupil is supplied with a glass jar containing living caterpillars, pupae, and leaves of the food plant. For class study, the caterpillars are kept in cages and fed moistened leaves until they spin their cocoons.

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Dried specimens in Riker mounts serve for the study at this time of the external features of the Cecropia or Polyphemus moth. The cocoons which were spun in the laboratory are put away in the laboratory or in a closed box out of doors where they are left until time for the appearance of the adult moth when they are placed in the cages so that the processes may be watched by the pupils. It should be stated that the cocoons in the laboratory should be sprinkled occasionally with water during the winter.

Other life histories of Lepidoptera which may be worked out in the laboratory are those of the cabbage butterfly, black swallowtail butterfly, mourning cloak butterfly, monarch butterfly, and viceroy butterfly. If properly directed, pupils will bring much of this material into the laboratory where all of the pupils can watch the transformations.

While I do not place emphasis upon the systematic phase of the study, yet I do find it a good plan to organize the work on insects around eight or nine distinct orders and have the pupils learn thoroughly the distinguishing characteristics of each order. The insects can be classed later on any other basis which seems desirable, "Insects injurious to man and animals," "Insects injurious to garden crops," "Beneficial insects" being suggestive topics for such classification.

In order that the class may have early the data necessary for making a sanitary survey of the school district, the Diptera are taken for the second study. It is the intention in this work to show the house fly at its worst so I make no apology for bringing into the laboratory such repulsive material as a seething mass of wriggling maggots. I had little difficulty this year at the time the fly was the topic in stocking my laboratory garbage can with an abundant supply of fine material by making a few select scoops of garbage from a pail which I found without a cover near the school.

The material with which each pupil is supplied at the beginning of the study of the house fly is a cotton-stoppered glass tube containing several full-grown maggots. But introducing the garbage can this year gave the pupils an opportunity to see without a great stretch of the imagination the effect of carelessness in the disposal of garbage. One peep into our garbage can was sufficient to drive the lesson home. At the close of the day's work the tubes containing the maggots are left lying on the side so that the maggots can reach the cotton into which

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they will work their way to pupate. In all probability some pupae are found when the class returns the following day. The pupae develop in the cotton and in due time come out of the cotton as full-grown flies. The pupils will surely see some of them emerging from the puparium. In case a pupa has formed between the plug of cotton and the side of the glass tube, the method an emerging fly uses in working its way through solid media by means of the bladder-like structure which extends from the front of the head is observed by the pupils with great interest.

Because of its relation to human welfare the mosquito must be included in any well-ordered course in the study of the insects. Eggs, wrigglers, and pupae are usually found together in quiet streams and in ponds during the summer months. We have gotten them from standing water in a greenhouse in midwinter. These are studied in small aquaria. But I have also found this material good for demonstration, using a live cell on the stereopticon. It is not unusual to see the imago emerging while the image is being thrown upon the screen. A few small minnows placed in the aquaria and a film of oil placed on the surface of the water in the live cell demonstrate in a striking manner the methods which may be used in dealing with these pests.

The sanitary map which deals particularly with the relation of the existence of conditions favorable to the breeding of flies and mosquitoes to the prevalence of disease in the community should be started as outside work as soon as the work in class with the flies is finished. We have a set of stereopticon views on the house fly as a carrier of disease which is used to introduce the work of the sanitary survey.

I have found by experience that when this work is begun it should be pushed through rapidly. The pupils will get more data in a week if crowded than they will get in a month if the work is allowed to drag.

The school district is divided into approximately equal small districts, each containing eight or ten blocks, and a small district is assigned to one student or in the case of the girls to two working together. A mimeographed sheet directs each pupil to make a map of his assigned district. On this map are located cases of transmissible disease. Sanitary conditions which are to be located are cesspools, sewage dumps, sewer outlets, marshes, stagnant pools, open garbage pails, and manure heaps. Other data shown on the map are public restaurants and stores where

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flies are allowed access to food, and places where there is much spitting on floors or walks. Each pupil is asked to write a summary of the conditions as he found them and try to show some connection between the health of the community and the sanitary conditions, especially with reference to the possibility of transmission of disease by flies and mosquitoes. Along with this summary is given an estimate of what remains to be done to make the community an ideal place in which to live. The boys and girls as citizens of the community are thus brought face to face with the fact that the problems of a city are of vital interest to everyone alike and everyone should have a part in their solution. Our people need to grow up in an atmosphere which will tend to develop a civic consciousness based upon the idea of individual responsibility.

If one will take the mortuary statistics of a city or county by months for a year and arrange the data to form a graph of deaths from diarrheal diseases in children, a curve is formed which rapidly rises with the appearance of flies and gradually falls as the flies disappear. There are approximately three times as many deaths from these diseases in August as there are in January. There may be other reasons, but the filth fly is certainly a prominent contributing cause.

While we are insisting upon clean premises it cannot be emphasized too strongly that eternal vigilance will go a step farther than to destroy the breeding places for flies; it will lead to the destruction of the breeders. I am inclined to think that it is good zoology to include instruction in the construction of the best fly trap and direction as to how such a trap should be used. In this connection I desire to call attention to an article on the subject by Dr. Hodge in the February, 1916, issue of the *Nature Study Review*. Quoting from this article, "Let it generally be known that wherever filth flies are, there is filth and the likelihood of disease, and that no clean people will buy food in filthy, fly-besmeared stores or feel at home in fly-filled houses, and we will soon begin to live in a decently clean country."

The best specimen of living beetle available at the time that insect is wanted for our work is the locust beetle. It is found upon the blossoms of the goldenrod. With its black and yellow stripes it fits into the pattern of the shadow and yellow of the blossoms, exhibiting protective resemblance to a remarkable degree. The beetle has been referred to as an example of the so-called protective mimicry. It is supposed to mimic a wasp.

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Each pupil is given a tube stopped with cotton and containing a sprig of goldenrod and one or more of the beetles for the laboratory study. I have not found it possible to find the borer and pupa of this beetle, so have had to depend upon preserved specimens of the June beetle for the study of the grub and pupa of the beetle. It is possible that both of these might be found alive in compost heaps at the time when needed. Meat and fish scraps placed in a quart fruit jar, the jar uncovered and placed on the side among the weeds of a vacant lot, will attract scavenger beetles and give an opportunity for studying a most interesting life history. Ladybird beetles, adult and larvae, placed in cotton-stoppered tubes with plant lice, offer interesting studies in the habits and transformation of an insect which is of considerable economic importance.

The Hemiptera may be illustrated in the laboratory by several of the larger bugs, giant water bugs, cicada and others, but I have found it best to study bugs in the field.

The squash bug can usually be found in the gardens in various stages of development during the early fall. For the city student, information concerning the identification, habits, and control of plant lice and scale bugs is decidedly practical and should be treated thoroughly. The same may also be said of this work for the pupil living in the country town or on the farm. I am convinced that a good spray outfit should be a part of the equipment of every high school laboratory.

Within three blocks of the school building we find scurfy scale, oyster-shell scale, cottony maple scale, woolly apple aphis, and several other aphids of lesser importance. It is quite necessary that the pupils be shown these pests in place on the trees. They can study the effects of the insects upon the trees and they will be able to identify them if any appear upon their own shade trees and shrubbery at home.

The dragon fly, nymph and imago, is studied as a type of beneficial insect. The nymph can usually be scooped up with the mud from some pond while the imago can be seen on almost any field trip in the early fall. External structure must be studied, however, from alcholic material or dried specimens in glass cases.

The study of the grasshopper can be left until late in the season, since good living specimens can be obtained up to the time of heavy frosts. I usually have no trouble in picking from weeds and bushes on cool October mornings all of the specimens needed.

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Along with these are usually found other members of the Orthoptera, true grasshoppers and walking sticks being notable examples. Theoretically, the study of the grasshopper as typical of insects in general in structure and physiology should be taken up as the first study of the course, yet this is impracticable since many of the forms of insect life have disappeared by the time an extensive study of the grasshopper could be finished.

The honeybee is the standard type insect representing the Hymenoptera. We have a hive of bees just outside the laboratory window which furnishes abundant material for study. The best season for observing the various activities going on in a beehive is May or June. Dr. Hodge's *Nature Study and Life* gives a full description of the possibilities of a bee colony in the schoolroom.

In every case where possible in the study of the insects the specimen should be studied alive. But preserved and dried specimens are necessary. Especially is this true in the case of complete life histories and with material to show damage done by insects. There must be a laboratory collection to supplement the material which can be picked up as needed for study. This calls for a suitable method of preserving and displaying specimens. The Riker mounts serve an excellent purpose, but they allow view from one side of the insect only. A case which serves the purpose better has glass on both sides, the two being kept apart at the proper distance by a frame made of thin strips of wood to which the glass plates are glued and the whole is bound with passe partout. The insect or other material is stuck to one of the glass plates with white shellac in any desired position. The method is described fully in *Nature Study and Life*, and more recently in Volume II of the *Nature Study Review*.

Most of the work of preparing mounts is work for the teacher and not for the pupil, since only in exceptional cases will a pupil make a respectable mount of a delicate specimen.

To be able to teach the subject of insects to the best advantage, the teacher must be thoroughly acquainted with his field. He must know where and when his material can be secured. It is a good plan to keep a diary as a guide for the work of future years. Every field trip with the pupils must have a definite purpose. The work should be discussed in class before the trip is made and after it is completed.

I am thoroughly convinced that the collecting which the pupils do should be done according to some definite purpose. It may

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be for the sake of showing complete life histories, or for showing the relations of insects to plants, or by any other definitely organized practical plan. I am doubtful of the advisability of starting the pupils out to see what they can catch with no other purpose than that of getting a collection of "bugs." Pupils should be encouraged to bring home and into the laboratory living material by means of which life histories can be worked out. I am of the opinion that the pupil who brings in a caterpillar of the tussock moth and feeds it until it makes its cocoon and watches the female emerge and lay her eggs on the pupa case has gained more power and useful information than could be gained by the same individual by sticking pins through dozens of unfortunate specimens of insects taken at random and with no definite purpose in mind.

It has proved an excellent practice in the Senn High School to complete the study of insects with several charts which summarize, under various heads, the data which have been worked over in the class and in the laboratory and field. The pupils are aided in making these charts by bulletins, a supplementary text, and books from the library.

A Summary of the Study of Insects is intended to fix definitely the main characteristics of the eight or nine orders of insects which have been studied.

Insects Which Affect Man and Animals groups together the insects which carry disease or are pests affecting other animal life and lists useful information with regard to these forms.

Insects Injurious to Plants shows the economic relations of a select list of insects with regard to plants affected, damage done, and remedies.

Controlling Insect Pests deals specifically with the methods used in destroying insect pests.

The measure of a course is, to some extent, information stored up, but a better criterion includes power developed. The work with the study of the insects should aid in the development of a citizen alive to his own interests but also alive to those of the community.

"Fertilization is a substance which helps lay the eggs and give it its food."

"Weevils are animals which kill chickens at night."

"The ecliptic is the path of the sun upon the earth."

"A spectroscope is the condition a given light takes when it is separated into its constituent colors."

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A GRAPHICAL SOLUTION OF THE EQUATION,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2} + \ldots\ldots$$

By J. H. V. FINNEY,
University of Colorado, Boulder, Colo.

This equation occurs frequently in the solution of problems in physics and electrical engineering. For example the resistance of parallel circuits is given by

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots\ldots$$

The total capacity C of condensers in series is

$$\frac{1}{C} = \frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3} + \ldots\ldots$$

And the relation between focal length F, and the distances p and q, of an object and image, from the vertex of a mirror or lens, is

$$\pm\frac{1}{F} = \frac{1}{p} \pm \frac{1}{q}.$$

The following graphical method of solution, which was suggested by Problem 931 of Shearer's *Notes and Questions in Physics*, has proved useful to the writer and may be of interest to others. It is short, easily understood, and its accuracy can be made whatever the conditions of the problem may warrant.

A suitable arbitrary scale, as shown in Figure 1, is laid off along horizontal and vertical axes taken on a sheet of cross section paper ruled decimally. If both axes are laid off to the same scale, a line OB is drawn to make an angle of 45° with each, and the solution of the equation is accomplished as follows:

A straight edge is laid connecting the points $(a_1, 0)$ and $(0, a_2)$. The ordinate (or abscissa) of the intersection of the straight edge and the line OB is the desired value of A.

Proof: The equation of the straight edge is

$$\frac{x}{a_1} + \frac{y}{a_2} = 1.$$

The equation of the line OB is

$$y = x.$$

Solving these simultaneous equations we get the intersection,

$$y = x = \frac{a_1 a_2}{a_1 + a_2},$$

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which is the same as we get by solving for A in the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2}.$$

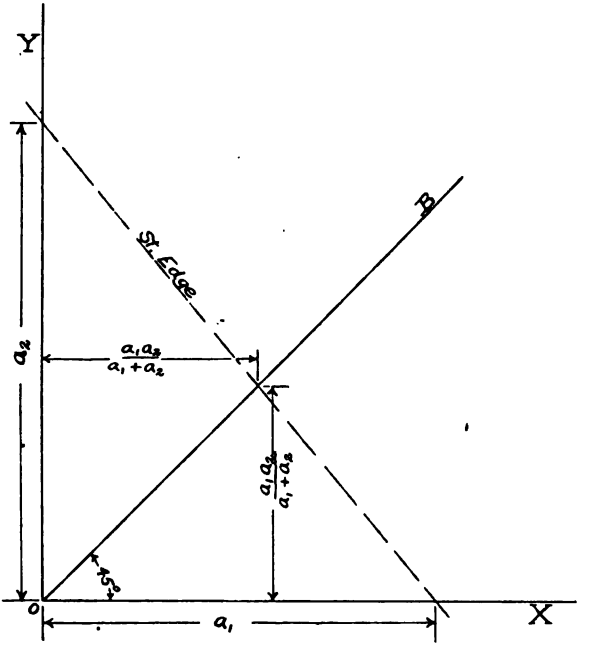

FIGURE 1.

To solve the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2} + \frac{1}{a_3} + \frac{1}{a_4} + \ldots + \frac{1}{a_n},$$

the straight edge is laid from a_1 on one axis to a_2 on the other. The intersection of the straight edge with the line OB gives us A_1, where

$$\frac{1}{A_1} = \frac{1}{a_1} + \frac{1}{a_2}.$$

Our equation now becomes

$$\frac{1}{A} = \frac{1}{A_1} + \frac{1}{a_3} + \ldots + \frac{1}{a_n}.$$

The straight edge is now laid from A_1 to a_3, and the intersection gives A_2 where

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$$\frac{1}{A_2} = \frac{1}{A_1} + \frac{1}{a_2}$$

We proceed in this way until we have used all the n terms, which gives us the desired value of A.

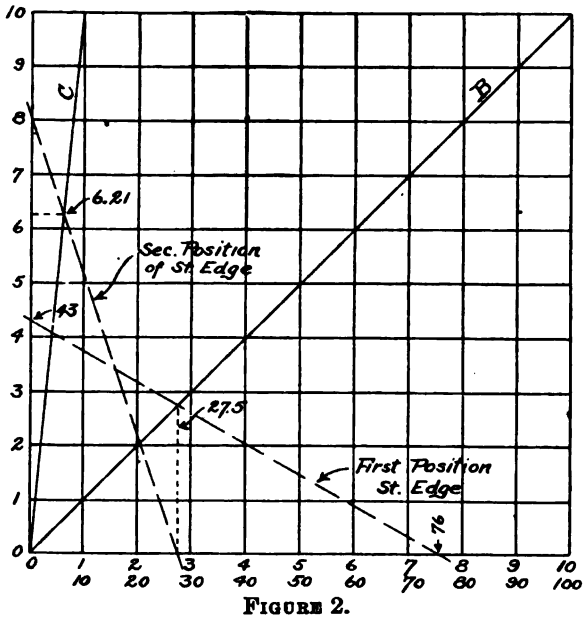

FIGURE 2.

It is evident the above is true when both abscissa and ordinate are multiplied by any number as 1/10, 10, or 100, making the same chart serve for all magnitudes.

If some values of a are of the order of ten times the magnitude of others, we may make the readings easier by the following modification:

The axis of abscissa is scaled from 0 to 10 and from 0 to 100, as shown in Figure 2. A second line OC is drawn through the points (0, 0) and (10, 10), using the large abscissa scale. Now, in the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2},$$

if a_1 is of the order of ten times the magnitude of a_2, we find A at the intersection of the straight edge and the line OC, and the result is read on the ordinate scale. This is evidently true for the line OC has the same 45° slope as the line OB, it being drawn to a different abscissa scale.

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Example: Find the resistance of three conductors in parallel which have respectively 43, 76, and 8 ohms resistance.

Solution: See Figure 2. Place the straight edge from 43 to 76 and the intersection of this with the line OB gives us 27.5 on the abscissa. Placing the straight edge from 27.5 to 8, the intersection with the line OC gives us 6.27 ohms, which is the desired result.

In the case of a lens or mirror, where F and q may have + or − values according to whether the image is real or virtual, our chart must have both + and − values, and such a chart is shown in Figure 3.

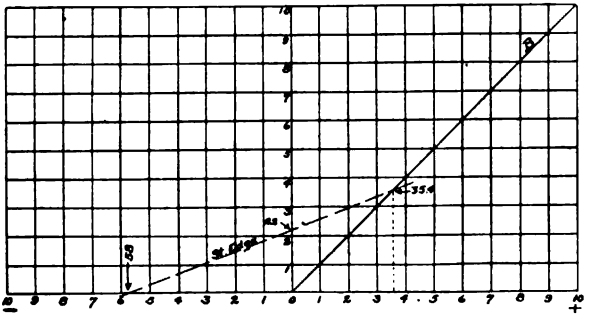

FIGURE 3.

Example: Find the focal length of a lens which, if an object is placed 58 cm. in front, gives a virtual image 22 cm. from the lens.

Solution: In this case F and q are negative, but if we change signs through the equation we may take F and q as positive and p negative. Placing the straight edge from −58 to 22 and prolonging until it crosses the line OB we find the desired focal length to be 35.4 cm.

MINERAL RESOURCES OF SOUTH CAROLINA.

The mineral resources of South Carolina are largely undeveloped and therefore the value of the annual production, amounting to about $1,500,000, is small as compared with that of most states. Clay, stone, and phosphate rock greatly exceed all other mineral products in value of production.

As a result of the war, many industries in the United States are being revolutionized, and this is especially true of the industries dependent on mineral products. American industries formerly using minerals imported from Europe are now almost entirely cut off from that source of supply. Certain of these minerals are known to occur in commercial quantities in South Carolina, and detailed investigation would probably result in the discovery of others. The demand for products, no longer obtainable abroad, makes it possible to work deposits in this country that were unprofitable under former conditions.

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At present there is a serious shortage in the supply of two mineral products, pyrite (a sulphide of iron) and manganese ore, both of which are essential for the successful prosecution of the war. Virginia leads all of the states in the domestic production of both pyrite and manganese ore, but South Carolina is at least "doing her bit."

Most of the pyrite used in making sulphuric acid has in the past been obtained from Spain, and large quantities were imported into Charleston each year for use in the fertilizer plants of the state. The demand for sulphuric acid in the manufacture of explosives has increased enormously, and now we are receiving practically no pyrite from Spain. The shortage is being supplied in part by native sulphur from Louisiana and Texas, but this is much more expensive, especially where it is burned in a plant designed for the burning of pyrite. Recently one of the old gold mines of South Carolina was reopened and now it is producing pyrite. There are probably other pyrite deposits in the state which could be profitably worked under present conditions.

Manganese is essential in the production of high grade steel, and it is estimated that the domestic production for 1917 will amount to about six per cent of the ore needed. Between twenty and thirty ships are said to be engaged in bringing ore from Brazil. The shipping problem is growing more serious every day, and yet manganese ore must be obtained if steel making is to be continued at the present rate. Within the past year manganese deposits were opened up near McCormick, and recently it was reported that two carloads of ore were being shipped weekly. There may be other deposits in South Carolina.

There are inexhaustible supplies of kaolin, or white clay, in South Carolina. At present they are being used chiefly in the manufacture of paper, but a process of discoloring kaolin is now reported as successful, and this may make large deposits available for the manufacture of white ware and pottery. The value of clay, mainly kaolin, imported into this country from Europe and China during 1913 exceeded $2,250,000. Before the war much of the clay used in the manufacture of glass pots was obtained in Germany, but today it must all be obtained at home.—[*University News.*

MAY FIGHT PINK BOLLWORM IN MEXICO.

Discussing the present appearance in Texas of the pink bollworm, a highly destructive cotton pest, the Secretary of Agriculture, David F. Houston, writes in his annual report:

"It is planned to establish a cotton-free zone in Texas, approximately fifty miles in breadth, along the Mexican border. It is proposed not only to eliminate cotton culture in this area but also to eradicate all volunteer cotton. Similar zones will be established to include any infested areas in Texas or the other Southern States. Furthermore, the cotton grown on the Mexican side will be kept under observation, and the department will cooperate with the Mexican Government, local authorities, and plantation owners in stamping out any outbreaks within fifty miles of the border. If the assistance of the Mexican Government can be secured, a thorough survey will be made of all Mexican cotton regions to ascertain the present distribution of the insect. This survey ultimately would be the basis for determining the possibility of exterminating the pest in Mexico. It may appear that the most effective and economical method of preventing the further invasion of the United States by the pink bollworm will be to undertake this task. It would involve large expenditures, but the seriousness of the situation might amply justify them."

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VALID AIMS AND PURPOSES FOR THE STUDY OF MATHEMATICS IN SECONDARY SCHOOLS.

By ALFRED DAVIS,

William and Mary College, Williamsburg, Va.

Chairman of a Committee of the Mathematics Club of Chicago Appointed to Investigate This Topic.

(Continued from the February number.)

7. *Mathematics Gives Ability to Handle a Tool, Essential in Much of Life's Work.*

Failure to recognize this often makes trouble for the student later. Prof. A. R. Crathorne, of the University of Illinois, says, "we have in the University of Illinois graduate students in agriculture who find themselves under the necessity of delaying the work in which they are directly interested in order to study the freshman algebra that they find essential to the study of their problems" (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, p. 420). And further, "The utility of algebra as a medium of expression is on the increase as surely as we are gaining more exact scientific knowledge" (*Ibid.*). The list of courses for which mathematics is an essential prerequisite, as given by a committee of this club (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, pp. 610-611) is as follows: scientific agriculture, engineering, physics, chemistry, art (drawing, designing, architecture, modeling, life and still life drawing, handicraft), pharmacy, dentistry, navigation, astronomy, naval and military engineering, domestic science, insurance, forestry, commerce and administration, railway administration, political economy, sociology, hygiene, sanitation, education, medicine, and journalism. Law and theology are included with some reservations. It is not difficult to see that a knowledge of algebra and geometry is absolutely essential for some of these courses, while in the others it has important uses, particularly the formula, the graph, and the equation of elementary algebra.

The man of ordinary education needs a knowledge of mathematics to appreciate everyday literature on many topics. Reading the many books and magazines relating to the automobile, the aeroplane, progress in science, or the war, without this as a foundation, is like reading about various places of interest without a knowledge of place geography. Prof. S. G. Barton, of the Flower Observatory, University of Pennsylvania (*Science*, vol. 40, p. 697) says that in the Encyclopedia Brittanica (11th

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ed.) there are 104 articles which use the calculus, of which about one-fourth are pure mathematics. Some of these articles are: clock, heat, lubrication, map, power transmission, ship building, sky, steam engine, etc. There is much greater need for a knowledge of algebra and geometry in everyday reading. Prof. D. E. Smith, of Columbia, says, "Of the necessity for knowing number relations there can be no question, but fifty years ago one might well have cried the slogan abroad from the housetops, 'Will anyone tell me why the girl should study algebra?' Today a person would sadly feel his ignorance if he or she had to look with lack-lustre eyes upon a simple formula such as may be found in *Popular Mechanics*, *Motor*, the *Scientific American*, an everyday article on astronomy, a boy's manual on the airplane, or any one of hundreds of articles in our popular encyclopedias. These needs come not only within the purview of the boy; they are even more apparent in the case of the girl, she who is to have the direction of the education of the generation next to come upon the stage of action. Each must know the shorthand of the formula, and the meaning of a simple graph, of a simple equation, and of a negative number, or else must feel the stigma of ignorance of the common things that the educated world talks about and reads about." *T. C. Record* May, 1917.)

It is not enough that we aim at the application of the results which others have worked out. We must go deeper than that. An *intelligent* use of mathematics *demands* a knowledge of the subject. It is the testimony of a teacher in a correspondence school that a student can in a few lessons learn the application of a formula to a particular situation; but that when a new situation arises there is no resourcefulness to meet the new need. The student has not mastered the subject. His place in the industrial world must be that of a machine. A. R. Forsyth, President of the British Association for the Advancement of Science, Sec. A, says regarding the Perry movement, "Something has been said about the use of mathematics in physical science, the mathematics being regarded as a weapon forged by others, and the study of the weapon being completely set aside. I can only say that there is danger of obtaining untrustworthy results in physical science if only the results of mathematics are used: for the person so using the weapon can remain unacquainted with the conditions under which it can be rightly applied. . . . The results are often correct, sometimes incorrect;

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the consequence of the latter class of cases is to throw doubt upon all the applications of such a worker until a result has been otherwise tested. Moreover, such a practice in the use of mathematics leads a worker to a mere repetition in the use of familiar weapons; he is unable to adapt them with any confidence when some new set of conditions arises with a demand for a new method: for want of adequate instruction in the forging of the weapon, he may find himself, sooner or later in the progress of his subject, without any weapon worth having." . . . "The witness of history shows that, in the field of natural philosophy, mathematics will furnish the more effective assistance if, in its systematic development, its courses can freely pass beyond the ever-shifting domain of use and application." (Perry's "Teaching of Mathematics," p. 36, and *Nature*, vol. 56, p. 377.)

The study of mathematics is useful in giving set and balance to one's life. The more widespread its study and the resulting mathematical sense the less opportunity there will be for dishonest practices by the unscrupulous man of affairs; a sort of intuitive sense of the correctness of business transactions will often prevent errors and losses; the elements of chance and luck will play a less important part in our affairs and superstition, the stronghold of ignorance blocking the way of progress, will be demolished.

8. *Mathematics Gives Training in the Use of a Symbolic Language.*

Much of the world's work is done by the use of symbols. They are the tools for rapid thinking and writing. The progress mankind has made would be impossible without them. We are convinced of this when we think of carrying on the simple operations of multiplication and division without the use of figures. Newton's law of gravitation: $F = GMm/D^2$, where F is the force acting between two bodies, M and m are the masses of the bodies, D the distance between their centers, and G the constant of gravitation, would be cumbersome indeed if it were necessary to say it the long way in order to use it. By the use of the algebraic symbols the whole story is gotten at a glance, and in a form convenient for application to other problems. There is economy of mental effort as well as of time. The importance of symbols is further illustrated in the fact that Newton chose a clumsy system of notation for the calculus while Leibnitz chose the present system, which is much better. The English adopted Newton's method and so fell far behind the

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mathematicians of the continent in development and application of the calculus. A reprint from the *Engineering Supplement* of the *London Times*, June 19, 1910, says, "The extent to which mathematics is capable of exact prediction depends on expressing the problem in mathematical language. The greater ability of engineers of today to translate problems into this language has led to an increasing number of successful inventions." The interpretation and application of formulae is necessary in the reading of all sorts of current literature, and in the application of general principles to all sorts of human effort. Algebra and geometry offer unequaled opportunity for the mastery and use of symbols, since the solution of problems requires constant translation back and forth. Dr. Smith (*T. C. Record*, May, 1917), "One merit of mathematics no one can deny—it says more in fewer words than any other science in the world." (*The Nation*, vol. 33, p. 426), "The human mind has never invented a labor-saving machine equal to algebra." Lack of training in the use of symbols fixes very narrow limitations to one's life.

The graph has become one of the most important symbols in modern life. The meaning and use of the graph cannot be properly taught apart from algebra. We see at a glance the relationship of two interdependent variables at any stage. Prof. Crathorne (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, pp. 423-4) says, "The world is full of variables which depend on other variables, presenting to us the problem of finding out and exhibiting the manner of dependence. The office of the graphical methods of algebra is to exhibit this dependence to the eye, and not, as many textbooks would imply, merely to aid in the solution of equations. . . . In a recent book for workingmen in shop mechanics, a full page is devoted to an explanation of the stretch of copper wire for different loads. The author, no doubt realizing the vagueness of his explanation, then clearly sums up by a graph with three lines of English under it." The graph has become well-nigh indispensable in presenting statistics. Much labor is necessary to get facts from numerical data, while the graph gives the same information almost without effort and presents a picture to the mind that is easy to recall. The graph makes the function concept clear to the pupil. He is able to understand the meaning and something of the importance of "x is a function of y." When the graph is subject to a known law, as represented by an equation, it is a necessary step to the study of advanced mathematics.

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Regarding the saving of mental energy by a knowledge of mathematics, and by a mastery of the use of its symbols, Prof. Chas. H. Judd, of the University of Chicago ("The Psychology of High School Subjects," p. 131) says, "No student will know what mathematics is until he realizes the great economy of mental energy which this form of experience makes possible."

9. *Mathematics Develops the Imagination.*

G. St. L. Carson, in "Mathematical Education," p. 41, says, "The operations and processes of mathematics are in practice concerned at least as much with creations of the imagination as with the evidence of the senses." F. J. Herbart says, "The great science (mathematics) occupies itself at least just as much with the power of imagination as with the power of logical conclusion." Prof. H. H. Horne, of Dartmouth College, says, "Apart from its manifold applications, mathematics is the inevitable disciplinary element in the curriculum. It trains in the habit of logical and symbolic thinking, of precision and concentration, and it develops the imagination." The concepts of space and number relationships are fundamental in education. Col. F. W. Parker ("Talks on Pedagogics," p. 50, etc.) says, "I think we can truthfully say that form is the supreme manifestation of energy, and without a knowledge of form and without the power to judge form with some degree of accuracy, there can be no such thing as educative knowledge. . . . Form and number are modes of judging and are necessary to a knowledge of the external world. . . . The study of form and geometry are of fundamental, intrinsic importance in education." In the study of mathematics, images of one, two, and three dimensions are constantly before the mind. At first, objects and drawings are used to give clear pictures, but the student soon learns to depend on the imagination to reproduce the images and to frame new relationships. This is especially true in the study of geometry. In the discussion of a problem, all the possibilities of a given case must pass in order before the mind. Surely the imagination is used and cultivated in the study of mathematics.

A few well-selected problems in physics and astronomy, taught with appreciation by the teacher, will aid in the cultivation of the imagination and broaden the life of the pupil. These may relate to the velocity of light and the length of its wave; the relative sizes of the planets and stars and how these are measured; the distance of the planets and stars and the meaning of "light years"; etc. Experience shows that problems relating

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to such topics are fascinating to the student. Carson ("Math. Ed.," p. 10), says, "One of the few really certain facts about the juvenile mind is that it revels in the exploration of the unknown." Astronomy, in particular, leads the mind to the threshold of the unknown, and exposes it to the Infinite. Who can be little, or narrow, or prejudiced, if his imagination has been inspired by mathesis!

10. *Mathematics Leads to a Knowledge and an Appreciation of the Foundations of Science.*

All science is ultimately mathematical in its methods; the more completely it is developed the more mathematical a science becomes. Mathematics enables us to apply accepted laws to Nature's problems. In this way Newton's and Kepler's laws have been established and have been made to extend to almost infinite reaches into space and to unfold the mysteries of a universe of which we are an infinitesimal part. Astronomy was astrology until mathematics released it and it became a science. But even astrology depended somewhat on mathematics. Sir John Herschel ("Outlines of Astronomy," Introduction, Sec. 7) says, "Admission to its sanctuary (astronomy) and to the privileges of a votary is only to be gained by one means, *sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in this or any other of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range.*" It is through mathematics that we are gaining knowledge of molecules, atoms, electrons, ions; of the wonderful changes that are occurring in these and of the laws that govern them. Mathematics has well-nigh unlocked the secret of matter itself. Indeed, we could know little of chemistry, physics, or of any other science were it not for the aid of mathematics; witness the following testimony: Roger Bacon ("Opus Majus") "Mathematics is the gate and the key of the sciences. . . . Neglect of mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things of this world. And what is worse, men who are thus ignorant are unable to perceive their own ignorance and so do not seek a remedy." Kant, "A natural science is a science only in so far as it is mathematical." Laplace, "All the effects of nature are only mathematical results of a small number of immutable laws." W. W. R. Ball ("History of Mathematics," p. 503) "The advance

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in our knowledge of physics is largely due to the application to it of mathematics, and every year it becomes more difficult for an experimenter to make any mark in the subject unless he is also a mathematician." Comte, "All scientific education that does not begin with mathematics is defective at its foundation. . . . In mathematics we find the primitive source of rationality; and to mathematics must biologists resort for means to carry on their researches." J. F. Herbart, "It is not only possible but necessary that mathematics be applied to psychology; the reason for this necessity lies briefly in this: that by no other means can be reached that which is the ultimate aim of all speculation, namely *conviction*." Novalis, "All historic science tends to become mathematical. Mathematical power is classifying power." Prof. A. Voss, of the University of Munich, in a lecture in 1903 (quoted by T. E. Mason of Purdue in *Science*, December 15, 1916) said, "Our entire present civilization, as far as it depends upon the intellectual penetration of nature, has its real foundation in the mathematical sciences." Prof. Thos. E. Mason (*Science*, December 15, 1916), "Can you realize what would happen, just what stage of civilization we should be in, if all that is developed by the use of mathematics could be removed from the world by some magic gesture? Every branch of physics makes use of mathematics; chemistry is not free from it; engineering is based on its development; sociology, economics, and variation in biology make use of statistics and probability. Our skyscrapers must disappear; our great bridges and tunnels must be removed; our transportation systems, our banking systems, our whole civilization, indeed, must step back many centuries." The student who leaves high school without a knowledge of the importance of mathematics in science has a serious lack. Problems in algebra and geometry should, when convenient, relate to the various sciences. If the text does not furnish such problems the teacher should provide them.

11. *Mathematics Should Be Appreciated as One of the Greatest Achievements of the Human Intellect.*

In this respect there is the same reason for studying mathematics as for studying literature, language, art, or history, for it is only as we learn to appreciate the greatest in man's efforts, achievements, and aims that we can have the proper ideals and purposes in our lives. It is only through this knowledge and appreciation that one is able to take an intelligent part in the

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world and in the age in which one lives; that one can be a live force and not an encumbrance in the world. The path by which men have traveled is shown by history; literature and art beautify its borders; language furnishes the bond of unity; but science, including mathematics, is the pavement and even provides the light by which they walk. Indeed, mathematics is the greatest of the sciences. Hermann Hankel says, "In most sciences one generation tears down what another has built and what one has established another undoes. In mathematics alone each generation builds a new story to the old structure." The earth as the center of the universe, the corpuscular theory of light, the indestructibility of the atom, these and many other theories, at one time considered fundamental, are now fit only for the intellectual museum; but the contributions to mathematics endure. Dr. Smith (*T. C. Record*, May, 1917) says, in speaking of the theorem of Pythagoras, "Before Mars was, or the earth, or the sun, and long after each has ceased to exist, there and here and in the most remote regions of stellar space, the square on the hypotenuse was and is and ever shall be equivalent to the sum of the squares on the sides. All our little theories of life, all our childish speculations as to death, all our trivial bickerings of the schools—all these are but vanishing motes in the sunbeam compared with the double eternity, past and future, of such a truth as this." Surely we can appreciate Laisant when he says, "Mathematics is the most marvelous instrument created by the human mind for the discovery of truth"; and Leibnitz, who says, "Mathematics is the glory of the human mind."

Do we aim, as teachers, to give this appreciation of mathematics? It can be accomplished only by the study of mathematics, and not by a course *about* mathematics, as some have suggested. As well expect nourishment from talking about food as to expect knowledge and appreciation of mathematics from talking about it. More importance ought to be given the history of mathematics in our teaching. Much inspiration and enthusiasm can be gained from the lives of great mathematicians. And at appropriate times there should be given the student a prospective view of the richness and beauties of the subject to be realized by advanced study.

12. *Mathematics May Make An Important Contribution to the Aesthetic, Moral, and Religious Life of the Individual.*

Henri Poincaré (*Annual Report*, Smithsonian Institution.

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1909) says that mathematics has aesthetic value in the feeling of elegance in a solution or demonstration; in the harmony among parts, their happy balancing, and their symmetry. The feeling of elegance may come from unexpected associations and kinships among things. The sense of beauty is bound up with the economy of thought. We have seen high school pupils fascinated by the application of the binomial theorem; by the power and elegance of an algebraic solution; or by the Golden Section and other geometrical constructions. They are delighted with beauties in nature and art that are revealed for the first time through the study of algebra and geometry. Prof. S. G. Barton (*Science*, vol. 40) says, "Beauty is concealed by ignorance of the mathematics necessary for its interpretation. The student of mathematics will see that of which the untutored mind has no conception, because lying beyond its comprehension. . . . One of nature's demands in which she is inexorable is a study of higher—the highest—mathematics. The interpretation of her laws requires it.

"The massive bridge once wonderful because of its enormous size, when its principles of construction are understood, becomes a thing of beauty, a wonderful monument to the intellects of the designer and the constructor. The great tunnels, turbines, subways, are changed to objects of wonder, to those capable of understanding the difficulties overcome in their construction. The stars in the universe above, which nightly dissipate some of their light upon the earth, bespeak their Creator's glory in voices but faintly heard by those whose training does not enable them to comprehend the reign of law there prevailing. To such an one 'the heavens declare the glory of God' in a more real and exalted sense." Thus mathematics literally opens a new earth and a new heaven to us. It unlocks for us the "music of the spheres"; it reveals the thoughts of the Eternal.

The study of mathematics leads to clear thinking; to honest and patient effort; to reverence for truth; and must, therefore, have a large place in the building of character. B. F. Finkel says, "Mathematics is the very embodiment of truth. No true devotee of mathematics can be dishonest, untruthful, unjust. Because, working with that which is true, how can one develop in himself that which is exactly opposite? Mathematics, therefore, has ethical as well as educational value." Prof. H. E. Hawkes, of Columbia (*Mathematics Teacher*, March,

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1913) says, "What is simplest and most beautiful in the domain of pure mathematics too often corresponds to the facts of nature to be accidental. I contend that it is our privilege to point out, at every possible turn, this coordination of number and form, of formula and physical law, of unity between mind and nature. This is an experience of no mean moral value, to realize that our mathematical procedure is attuned to the harmony of the universe." In mathematics, then, the human mind relates itself to the Supreme Intelligence, whose thought is manifest in the universe; and the contact must leave its imprint on our lives. This leads us to the consideration of the religious value in the study of mathematics.

Man has an innate desire from early years to reach towards the Infinite and the Eternal. Clerk Maxwell, towards the end of his life, said, "I have looked into most philosophical systems, and I have found that none of them will work without God." Mathematics reaches farther and with greater certainty than any other philosophy; towards a Supreme Being, a great First Cause. It looks down the vistas of the ages past; and into the dimness of the eons to come; and the human mind is awed by the sublime majesty of the Divine. Prof. D. E. Smith says, "The proper study of mathematics gives humanity a religious sense that cannot be fully developed without it. . . . In the history of the world, mathematics had its genesis in the yearning of the human soul to solve the mystery of the universe, in which it is a mere atom. . . . It seems to have had its genesis as a science in the minds of those who followed the course of the stars, to have had its early applications in relation to religious formalism, and to have its first real development in the effort to grasp the Infinite. And even today, even after we have been pushing back the sable curtains for so many long centuries—even today it is the search into the Infinite that leads us on." Col. Parker ("Pedagogics," p. 46) says, "I can assert that, from the beginning, man's growth and development have utterly depended, without variation or shadow of turning, upon his search for God's laws, and his application of them when found, and that there is no other study and no other work of man. We are made in His image, and through the knowledge of His laws and their application we become like unto Him, we approach that image." . . . "There is but one study in this world of ours, and I call it, in one breath, the study of law, and the study of God." That the study of mathematics is the study of

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God's laws and so must lead to God there can be no question. Plato, "God eternally geometrizes." C. J. Keyser says, "Again it is in the mathematical doctrine of invariance, the realm wherein are sought and found configurations and types of being that, amid the swirl and stress of countless hosts of transformations, remain immutable, and the spirit dwells in contemplation of the serene and eternal region of the subtle law of Form —it is there that Theology may find, if she will, the clearest conceptions, the noblest symbols, the most inspiring intimations, the most illuminating illustrations, and the surest guarantees of the object of her teaching and her quest, an Eternal Being, unchanging in the midst of the universal flux."

> "And reason now through number, time, and space
> Darts the keen lustre of her serious eye;
> And learns from facts compar'd the laws to trace
> Whose long procession leads to Deity."
> —Jas. Beattie, "The Minstrel," Bk. 3.

No wonder the mind is fascinated by the fields opened through the study of mathematics. One is led to a spirit of reverence when he contemplates the human intellect as revealed in the ever unfolding and almost limitless range of mathematical achievement. It reveals and inspires Godlikeness. Mathematics deals with the eternal verities: it is, if you will, the majestic mountain peak that rises in sublimity above the clouds of doubt and uncertainty and basks in the sunlight of eternal truth.

These values in the study of mathematics will suggest the more important aims and purposes for its study and its teaching. The teacher will do well to have them in mind as a background for his teaching; in this way they will permeate and vitalize his work. But this is not enough. The pupil must also appreciate their importance, to give sufficient motive for his work, to satisfy him that the study is worth his effort. Not all pupils will appreciate these to the same extent. The teacher should ascertain the interests of the student and make the appeal chiefly in accordance with these interests. Bertrand Russell says, "Every great study is not only an end in itself, but also a means of creating and sustaining a lofty habit of mind; and this purpose should be kept always in view throughout the teaching and learning of mathematics." The same is true of all purposes; neither teacher nor student should work blindly without knowing what to expect as a result of his effort.

We have made our defense for the teaching of mathematics in high schools when we have shown that some of these values

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can be realized alone by the study of mathematics, and that others can be realized better through mathematics than by the study of any other subject. We have shown that mathematics is most important in its culture values—that it is indispensable to everyone who would live his best. We might add the words of President Hadley of Yale, "The value of an education largely consists in studying facts that will not be used in after life, by methods that will be used." Dr. Snedden, of Teachers College, recognizes the fact that the chief claim for the study of mathematics is on the cultural side. In "Problems of Secondary Education" (recently published), p. 223, he says, "I am convinced that the prominence of algebra (and geometry) in secondary education rests not so much upon faith in its usefulness as a tool of further learning as upon belief in its value as a means of 'mental training' and upon the faith that somehow a knowledge of algebra is essential to general culture." Again (p. 229), speaking of a secondary school curriculum, he would "Seek to develop a 'culture' course in mathematics which should prove attractive to students seeking to inform themselves about the world in which they live; this to include some account of the evolution of mathematics as a human tool and as a means of interpretation, as well as a survey of modern applications of mathematics to the understanding of the universe and to the work of the world. Just as many of us can respond to operas, epics, and great paintings without being artists in these fields, so I think many could be led to appreciate the place of mathematics without becoming mathematicians." In the light of what we have said, we would change "should prove attractive," to "should be made attractive," throwing responsibility upon the teacher. We would *require* a course in mathematics of everyone. We would make this course to include the actual study of mathematics; for while we would not seek to make mathematicians of all students, in the sense of making each a specialist, everyone needs to study mathematics as well as to study *about* it. And further, the cultural value of mathematics is of immeasurably greater importance than the mere getting of information about things. However, a knowledge of mathematics is essential in much of life's work; and it is evident that it will become more and more important as a means of investigation in practically every field of endeavor.

Let us remember, withal, that the greatest values and aims in the study of any subject, like all the greatest things in life,

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cannot be easily reduced to exact measurement. We have heard Dr. Smith say that he wished someone might measure the value of the early study of Greek in his life. So far no one has, and it is not likely that the psychologist ever will invent a measure for such values. Therefore, while we satisfy ourselves and seek to satisfy others by giving reasons for our faith in, and enthusiasm for, the subject we teach, we do not hope to close the door to the questions of doubters and critics. Nor do we think the door can ever be closed or ever should be. It is the glory of mathematics that, while it has had destructive critics through the centuries, it has survived them all and is marching steadily onward to a higher and a surer place in our civilization. Like everything worth while, it has its critics and enemies, but these ultimately contribute to its strength. They aid mathematics in leading its advocates to establish more firmly its claims, to adjust it better to changed conditions; and they are the means of heralding its worth to the multitude. This is the logical outcome of present criticism.

(To be Continued)

VALUABLE TOPOGRAPHIC MAPS.

Comparatively few people realize the value of the topographic maps which are being published by the Government. There is no state some of whose area has not been covered by these topographic surveys, the resulting maps of which convey more useful information of their areas than any other maps. They portray accurately the physical features of the country, the hills and mountains, valleys and slopes, streams and swamps, as well as every work of man, such as railroads, wagon roads, bridges, and houses and other buildings. A single feature of the map which makes it well worth having is that it shows the altitude or elevation of every point in the area; it is a detailed dictionary of altitudes.

The maps are printed in three colors, black being used to indicate houses, roads, names of towns—the human features of the map—blue to indicate the streams and lakes and other water features, and brown to indicate the valleys and hills, whose elevations are shown by means of contour lines. Some of the maps are printed with a fourth color, green, which is used to show woodlands. The topographic map is in fact an accurate relief model of the area mapped.

The maps are in increasing demand not only by engineers, for whom they constitute base maps of the greatest value in planning all construction work, but by automobilists, hikers, and farmers whose homes are included in the areas. The Geological Survey, Interior Department, has already published 2,500 topographic maps, covering more than forty per cent of the United States. About 20,000 square miles of new country is surveyed annually, resulting in the publication of approximately one hundred new maps a year.

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THE INTRODUCTION OF DEMONSTRATIVE GEOMETRY.[1]

By ERNEST B. LYTLE,
University of Illinois.

"When you come to the geometry class you must leave your common sense behind," is the most astounding statement that I have ever heard a teacher make to students. Some time ago I was visiting a geometry class in one of the larger high schools of this state. The class was in the first week of geometry study; after the class had gone through formally the usual proof of one of the earlier theorems, a bright youngster remarked, "I don't see the use of all that talk. I knew that theorem was true before by my common sense." Then came this most startling statement from the teacher, "Fred, when you come to the geometry class you must leave your common sense behind." No wonder there was great mental confusion and little, if any, interest evident in that room.

I was introduced to demonstrative geometry by an attempt to prove the obvious theorem, "All straight angles are equal," and remember my distress at the fuss made over the truth of so simple a statement when its truth seemed to me self-evident to anyone with ordinary sense.

These are not uncommon experiences, judging from the many people who tell of the long time it took them to see just what the purpose and value of geometry was. Just this week an excellent teacher told me he believed that success or failure in geometry was very largely determined by the character of the first few weeks' work in the subject. Widespread dissatisfaction with the old formal methods and appreciation of the importance and difficulty of a good introduction to demonstrative geometry have roused interest in the question before us for discussion, "What is an effective way to introduce class work in geometry?"

Before beginning a course in demonstrative geometry it is desirable that the students take some preliminary work in observational geometry. For example, such a course as that in concrete geometry recommended by the N. E. A. Committee of Ten on Secondary Studies (Report 1894, p. 110), or as that given in Hedrick's little book on *Constructive Geometry* (Macmillan Co., 1916). But since such courses are found in few of our schools we will assume in this discussion no more preliminary

[1]Read before the November, 1917, Conference of High Schools with the University of Illinois.

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work in geometry than that which is gotten from drawing courses, arithmetic, and general daily experience. We will assume further that the work here outlined is for the ordinary class of second-year high school students, since demonstrative geometry is usually begun in the second year in most of our high schools. We offer no arguments for an informal beginning since there is quite a general agreement that such an introduction is necessary. That this need has long been appreciated in Germany, France, and Italy is shown by the numerous preliminary, or "propaedeutic," courses offered in their elementary and secondary schools, such as those outlined by Veronese, Holzmuller, and Simon, and by the able discussions of the merits of such courses as found in Reid's *Anleitung Zum Mathematischen Unterricht* (Berlin, 1906), in Schotten's *Inhalt and Methode des planimetrischen Unterricht* (Leipzig, 1890), and in Simon's *Methodik Des Rechnens und der Mathematik.*

There are three aims in this preliminary work: (1) to review, clarify, and informally develop from previous experience the fundamental notions of geometry; (2) to introduce the technical language of geometry, and (3) to create a feeling of need for proofs by slowly bringing students to the point of searching for reasons. We are too apt to forget that students beginning geometry already have much geometric knowledge which only needs to be clarified and translated into the technical language of geometry. Further, students will never appreciate what "geometry is all about" until they feel a real need for seeking reasons. The old and, unfortunately, too often the present practice of beginning by attempting to prove statements which seem perfectly obvious makes the whole subject of geometry seem trivial to the students and discourages interest. Carson well says, "one of the few really certain facts about the juvenile mind is that it revels in exploration of the unknown, but loathes analysis of the known" (*Mathematical Education*, Ginn & Co., 1913, p. 10). Klein is thinking of the same quality of the juvenile mind when he says, "At the beginning I pay no attention whatever to proofs, but am satisfied with the 'Behold' of the Hindus, until by very slow degrees I have brought my pupils to the point of searching for reasons" (*Jahresbericht der deutsch, Math. Ver., 1904*).

What principles will guide us in attaining these aims? (1) There must be either a direct or an indirect basis of sense perception: (2) that which is new or general must be made

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real by application to or connection with past experience; (3) the method must be that of analysis and induction rather than deduction; (4) there must be motivation through the early creation of a desire to find reasons for beliefs.

"There is nothing in the understanding which has not been first in the senses," is an old pedagogical maxim. Any idea we have if carefully analyzed may be run back to sense perceptions. This basis is shown by the difficulties in the education of such defectives as Helen Keller. So there must be some use for models and figures in beginning geometry as well as some measuring of lines and angles. But care should be taken not to overdo this work. Dewey says, "It is foolish to insist upon the observation of objects if the student is so familiar with the objects that he could just as well recall the facts independently" (*Democracy and Education*, p. 185). Frank H. Hall used pins stuck into flat cushions to give his blind students something in place of our figures. He said his blind students would use his pincushion figures only a few days because by that time they could imagine the figures and thought the pincushions a nuisance. It is deadening to interest to continue the use of models and concrete work beyond the point of usefulness. Basic sense perceptions are necessary in new experiences, but their continued use in familiar situations is both distasteful and detrimental.

"Vague generality" is a common term of criticism. General terms and general statements too frequently lack reality and do not carry meaning. Students seldom feel the need of following up definitions with one or two concrete illustrations or special cases. Teachers generally fail in developing the habit of illustration in their students, which habit is necessary evidence of reality or true comprehension.

Since textbooks in geometry almost universally present proofs in the deductive form there is grave danger that students will fail to see the true methods of originating proofs. Their great difficulty with originals is evidence of a lack of training in methods of attack or discovery. Have your students ever said, "Yes, I understand that proof and see that it is all true, but how did the author ever think of doing it that way?" Failure to develop the analytic and inductive methods of attack and too early emphasis upon deductive forms tends to simple memorization of proofs originated by others. "Scientific method applied to the teaching of solving mathematical problems means the method of discovery, the method of induction, the method of

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analysis" (*Scientific Method*, F. W. Westaway, p. 412). Deduction is the method for presenting final results where the false starts, the wrong suggestions, the study of special cases, and the unsuccessful trials of discovery have been left out; in presenting proofs in deductive form all the scaffolding of discovery has been removed. If students see only polished deductive proofs in the textbooks, and neither originate a proof by themselves nor witness the teacher discover a proof, there should be no surprise at their lack of ability in the discovery of proofs.

As suggested at the beginning of this paper, the first great difficulty in beginning demonstrative geometry is to make the students see the purpose of it, to make them feel what we are driving toward. The poorest possible beginning is in attempting to prove theorems which seem obviously true to the students. We should early make them see that we are trying to give valid reasons for our beliefs about geometric things. Simply stated, a proof consists in the production of facts as sufficient reasons to support some conclusion, implicitly challenging a denial of either the truth or the relevance of these reasons. The first step is to get the students to make some statements which they believe to be true about some figures they have drawn; these can be brought out by good questions from the teacher. The second step is to call for reasons for their belief, and the third step is for the teacher to attack and show insufficient some reason given. In the beginning, obvious reasons should be accepted without discussion, meanwhile watching for an incorrect reason to attack. Probably the first wrong inference will be that some lines are equal or parallel because they look equal or parallel. That appearances are often deceptive may well be shown by certain optical illusions, which the teacher keeps at hand for such purpose. (See *1908 Proceedings of the Central Association of Science and Mathematics Teachers*, p. 177, and Wentworth-Smith *Plane Geometry*, p. 15, for useful optical illusions.) Likewise measurement always appeals to beginners as a good reason for the truth of equalities in geometry. Although often using measurements to suggest truths, yet students must early be convinced of the difficulty of making accurate drawings, that measurements are at best only approximations, and that more simple and precise tests for equality are needed. The writer feels that the difficulty of making accurate measurements, their approximate character, and the feeling of repulsion which the abler students manifest for too much measuring, is not sufficiently

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appreciated by teachers. In an informal, conversational way students can be led to see weakness in their old methods of reasoning and to feel a need for better reasons for their beliefs; under a little skilful guiding they soon find delight in seeking reasons for their beliefs which will stand up against all attacks upon either their truth or relevance. Only after the students have attained some appreciation of the purpose of proofs should they be led to put their final results into the formal, precise, and elegant deductive form.

Having considered general principles, we shall now give them concrete application. The students should come to the first class provided with paper, pencil, ruler, compass, and protractor. Through oral directions teach the following constructions:

(1) To bisect a given line segment.
(2) To bisect a given arc of a circle.
(3) To bisect an angle.
(4) To erect a perpendicular to a line at a point in the line.
(5) To drop a perpendicular to a line from a point without the line.
(6) To trisect a right angle.
(7) To inscribe a circle in a triangle.
(8) To pass a circle through three points not in a straight line.
(9) To draw a line parallel to a given line through an exterior point.

Make no attempt here to give the usual proofs of these constructions; if students question their truth give them approximate verification by measurement. Next have the students write a description of each construction in a notebook. Thus for (3) they would write something like the following:

To bisect any triangle BAC.

With A as a center and any radius r, describe an arc intersecting the angle sides in M and L. With M as a center describe an arc of a circle; with L as a center, and with the same radius describe another arc intersecting the latter arc in a point K. Join K to A and the line AK is the required bisector.

While learning these constructions and writing [illegible] scriptions the students are introduced to the symbo[illegible] etry; they learn how to read lines and angles; us[illegible] single letter notation wherever p[illegible] While [illegible] being done in class periods under [illegible] n o[illegible] assign for home work related co[illegible] ob[illegible]

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"Construct a square," "Inscribe a square in a circle," "Construct an inscribed hexagon by bisecting the sides of an inscribed triangle," etc. Geometric designs involving the fundamental constructions may be used for home work. (Hedrick's *Constructive Geometry* will suggest home work to the teacher.)

During all this work the teacher should have before him a list of geometric terms which he expects to fix in the students' minds; such as point (having position only), straight line (length only, no breadth or thickness), plane, solid, rectilinear figure, parallel lines, curves, circle, radius, diameter, chord, angle, right angle, acute, obtuse, complement, supplement, interior, exterior, vertical angles, bisect, trisect, etc. Develop the meaning of each of these terms by means of questions and illustrations; ask the students to point out examples of these terms on their figures; ask them to find examples in objects about them; translate old expressions, like "corners fit," "square corner," etc., into geometric language; compare their definitions with dictionary and text definitions; make these terms meaningful by continued and careful use. The originality and questioning skill of the teacher will direct this work of fixing fundamental notions and correlating them with their daily experiences.

If we are to avoid attempting to prove that which seems obvious to the students, there must be a broader foundation of assumptions than is common in beginning geometry. So the teacher should also have before him a carefully prepared list of obvious geometric facts which he expects to use as assumptions in later proofs, such as the following: (1) All straight angles are equal; (2) All right angles are equal; (3) The shortest path between two points is the line segment joining the points; (4) Two distinct points determine a straight line; (5) Any side of a triangle is less than the sum of the other two sides; (6) A diameter bisects a circle; (7) A straight line intersects a circle at most in two points; (8) Complements (or supplements) of equal angles are equal; (9) Two lines parallel to the same line are parallel to each other, etc. (The introductory chapter in Young and Schwartz's, or Wentworth-Smith's *Geometry*, or the *Report of the National Committee of Fifteen on Geometry*, p. 20, will assist a teacher in making such a list of fundamental geometric assumptions.) In most cases the emphatic statement of these fundamental facts is sufficient to bring conviction of their truth: informal discussion will bring acceptance of the truth of all; draw figures illustrating these fundamental facts; seek illustra-

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tions in everyday experiences. After oral discussion has fixed these facts they should be carefully listed in the students' notebooks for future reference.

In order to make progress toward proving theorems, next develop with the class proofs for the simple theorems: (1) Vertical angles are equal; and (2) The bisectors of vertical angles form one and the same straight line.

Next take up the construction of triangles, from given data, as from two sides and their included angle, considering the usual four cases. Consider also their application to right triangles with necessary modifications in statement.

From this consideration of triangle construction make the transition to the formal proofs of congruent triangles as given in most texts, and begin from this point on to make use of the textbooks. By certain judicious omissions it is believed that this introductory oral work can be here connected up with any one of the textbooks now in common use.

Within the space here available, it is impossible to give all the details of the plan for introductory work here presented, but it is hoped that enough suggestions have been given to enable the teacher to complete all the details and adapt the scheme to his particular class and text. The length of time given to such an introduction must be determined by the preparation and the particular needs of each class. It may be quite short if students have had preliminary courses in constructive or concrete geomtry. The prolonging of such informal work when not needed will tend to disgust the abler students.

The writer knows of no text on demonstrative geometry which gives a sufficiently informal introduction, and doubts whether such work can be put into a text with as effective results as when presented in class by the teacher. Some texts (Wentworth-Smith, Wells-Hart, Young-Schwartz, Long-Brenke, for illustration) however have greatly improved the introductory work.

This is one way of introducing demonstrative geometry. I hope the suggestions will assist the skilful teacher in making the study of geometry real, interesting, and valuable.

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THE RELATION OF HIGH SCHOOL CHEMISTRY TO GENERAL CHEMISTRY IN COLLEGES.[1]

By C. L. FLEECE,
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In teaching general chemistry in colleges we cannot ignore the fact that a considerable portion of our students have studied chemistry in high school or preparatory school and that this elementary training will have an influence on their advancement. There is no doubt that we can teach these students more chemistry than beginners. But it is a problem to determine the exact advantage they may have and what credit may be given to their previous study of the subject.

This problem affects the colleges more seriously than the high schools, since a very small percentage of the high school graduates enter college and less than half of these have offered chemistry as an entrance subject. In an indirect way, however, it does have an important bearing on high school chemistry. If we cannot take high school graduates and use their knowledge of chemistry as a basis of a more advanced course, there is something radically wrong with their elementary training. And when I say this I would not have you think that high school chemistry should be *taught* as a preparatory course to future chemistry in college. In fact our elementary science courses in colleges, as well as in secondary schools, are frequently to be criticized because we look upon our pupils as future scientists and may teach them little that is of general educational value.

Those who teach elementary science in college are naturally inclined to consider that the ideal methods of teaching high school science are those that are miniatures of their own pet schemes. But we should expect high school students to come to us with a training meant to fit them for after life. It is the duty of the high schools to supply this and, if we put them in an advanced course in general chemistry, it should be one based on this idea. It is the only logical basis for such a course and probably the best that the high schools could possibly give us.

Very few colleges give two distinct courses in general chemistry, one for beginners and one for men who have already had an elementary training in the subject. Columbia has such an arrangement. At Harvard I believe the laboratory work is different. At Princeton we have different quiz groups, the lab-

[1] Part of an address before the Chemistry Section of the New Jersey Science Teachers' Association at Newark, December 9, 1916.

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oratory work is varied somewhat, and the courses will be entirely separate when the new laboratory is completed. But a number of colleges insist that the entrance requirements in chemistry must be on a par with those in other subjects, and after a student has passed those requirements and entered college his knowledge of the subject must be disregarded and he must elect a beginners' course. The colleges, as a rule, are not to be criticized for this state of affairs because two courses in general chemistry naturally mean a greater teaching force than one and a more complete physical equipment. These are often impossible to obtain.

Now comes up the question of the advisability of such a division, when possible, some of the obstacles, and the assistance the high schools may give to the plan. The statistics of the College Entrance Examination Board show that the percentage of students passing chemistry of late years is slightly below that of all subjects. And we may judge from this (assuming that the students get as good instruction in chemistry as in other subjects, and I believe they do) that the requirements are high enough to insure that a student will have considerable knowledge of the subject when he enters college. As to the part of that knowledge that may be the basis of a more advanced course, I shall speak later.

Let us now suppose that these students are put into a beginners course in general chemistry, and see what happens to them. They may be divided into three groups. First, those who are really interested and desire a further knowledge of the subject. Their work in high school was usually of such a high grade that they are prepared for rapid advancement and expect it. But they begin the course by hearing lectures that are too familiar to them to be very instructive or spectacular and by doing laboratory work that is too near a repetition of former trials to stimulate wonder or ingenuity. The idea of work of any variety is distasteful to some college students, but the repetition of work, once carefully performed, seems little short of criminal. And to be required to assemble a hydrogen generator for the second time and be exposed to the same dangers of an explosion seems much more of a waste of time to these students than if their mathematics course in college should begin with the multiplication table. Is it surprising that many in this group of students lose interest, become discouraged and do mediocre work, and finally forget their inclination toward chemistry?

The second group will include those students who think

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their knowledge of chemistry will make a beginners' course a "cinch;" and a third group will be made up of those who go into the course for no special reason other than because it is required, or makes a convenient schedule, or because their parents requested it. To both of these groups the results are often more disastrous than they might have been if they had had no elementary knowledge of the subject. It will require little study for them to do passable work for weeks or possibly a whole term; but before the year is nearly over they will find that they have neglected new ideas and new principles to such an extent that they cannot keep up with the class or pass their final examinations.

In a more general way we may say that any course which requires a widely different amount of mental exertion from two groups of students is defective from the standpoint of mental development and efficiency. And as these considerations outweigh all others in any elementary course, it is evident that such results as I have mentioned are not based on sound pedagogic principles.

There are difficulties to be encountered in accepting high school chemistry or physics as a foundation for a more advanced course in the particular science. A student's fitness to take up the more advanced course can be determined to only a small extent by his ability to pass the college entrance requirements and, paradoxical as it may seem, the schools that do not expect to prepare their students for college usually give them a sounder foundation for college chemistry than preparatory schools whose reputation is based on their ability to get students by the entrance examinations.

Although the college entrance requirements in such subjects as Latin, mathematics, or history may give us a fair estimate of a student's training in those subjects, they produce little evidence on numerous intangible factors that make for his proficiency in chemistry. A school that will look upon chemistry merely as a part of a general education will emphasize *quality* more than *quantity*. It will teach a student to *generalize* rather than *memorize*. And the training and analytical reasoning that may be developed in the laboratory are not sacrificed for cold facts that may later be put on paper. The chemical training that will help a man or woman to solve the problems of later life may, at the same time, meet the requirements of the College Entrance Examination Board or any similar board, and be the best asset toward progress in his college career.

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The so-called "requirements" of the Board are too broad to be covered completely by any secondary school (or college) and should rather be considered as a list of suggested topics, or not at all. And teachers sometimes fail to get their students through their entrance examinations because they pay too much attention to these requirements and not enough to thoroughness and the correct methods of making their courses interesting. An attempt to cover the requirements as far as possible often results in a "cramming" process that may be useful in getting students through their examinations, but leaves their knowledge in such a chaotic state that it is unsuited to any further purpose. It is quite possible for them to memorize a mass of facts relating to physical and chemical properties and uses of chemical substances, along with a number of definitions and laws, and squeeze through an entrance examination. They may not be able to write a formula or equation that had not been previously memorized; they may have no idea of nomenclature or the relations between elements or compounds; problems in chemical arithmetic may have been lightly passed over; and they may be barely acquainted with a chemical laboratory. Yet I can conceive of such students passing the entrance requirements in chemistry and believing that their knowledge should entitle them to an advanced course in general chemistry.

But the number of such exceptional cases is decreasing rapidly, and it does not take long to weed them out and drop them into their proper atmosphere. Better laboratories and equipment and higher standards among high schools are having their effect on the quality of work turned out.

Of course the most striking evidences of poor training are still to be found in a student's laboratory work, and this is the most difficult consideration to meet in giving credit to high school chemistry. This is due not only to the lack of laboratory facilities but to the fact that laboratory instruction for beginners is the most tiresome of the teaching of chemistry and is most likely to be neglected. This instruction is punctuated ("punctured" would be as good a word) by such daily happenings as illustrating the correct method of removing a stopper from a bottle, explaining that a rat-tail file really looks like a rat's tail and is not triangular, that hot glass should not be cooled under the tap, that the hydrochloric acid is within reach and not to be found on the sideshelf, and that the "bottle of glowing splints" has ceased glowing. In addition we may be

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called upon for police duty such as locating lost apparatus, putting out fires, and caring for the injured.

On such a day as this it will require a bit of self-control not to see imaginary precipitates and not to accept an apparatus merely because it "works."

Another thing that affects the laboratory training in some schools is the limited periods for such work and the desire to cover a set number of exercises. This sometimes forces a teacher to accept results that would be repeated if a student could find a period to do so and not fall behind the rest of the class. And if a student is hurrying through an exercise which should be finished before a bell concludes the exercise, he will usually miss the conclusion that should be drawn and gain little from the experiment. Also such things as poor cork boring and glass working are likely to be overlooked.

I saw a good example of this attempt to save time only a few days ago. I intended giving some extra work to a student who was unusually well prepared in textbook chemistry, and asked him whether he had had any experience with balances. He replied that his school had balances of different kinds but they were not required to use them, and were allowed to take their chemicals to the druggist to be weighed. That they saved time by so doing is doubtful, and if accuracy was the reason for such a procedure, a scientist was evidently wasted in a corner drug store. And the boy would have been better prepared for the work I assigned him if he had used only crude laboratory scales and had learned to replace weights.

It is a difficult matter to get much information on a student's laboratory training by an inspection of his laboratory notebook. Frequently the poorest students will be able to prepare the best looking books, and important conclusions and original work will be concealed with copied lists of apparatus and materials or lengthy instructions for performing the experiments. And I have seen books containing long lists of chemical formulas and their names which the students were supposed to memorize.

A large part of this memory work can be eliminated by a greater emphasis on the rules of nomenclature and valence. These are topics that will add little to a student's general knowledge but they will help clear up the confusion that results from this new language of chemistry. Previous study of grammar and languages has taught him that different endings are used merely to give different shades of meaning to words, and it is

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hard for him to grasp the idea that such compounds as sulphides, sulphites, and sulphates can be quite different substances. Nomenclature is usually not explained until a systematic study of acids, bases, and salts has been made, but I believe that the main ideas may be combined with valence earlier in the course. If you explain that there is a relation between the name and radical of a salt and the name and radical of some acid the writing of formulas and naming of compounds will at once assume a logical basis. The topic may be taught in an interesting way that will result in a spirit of rivalry in the class and the dread of meeting unfamiliar chemical substances will disappear. And the variety need not be limited to the compounds that have been studied in detail. One of the questions on the Board paper last June asked for the *name* of the *potassium salt* of *chlorplatinic acid* and the *name* of the compound that *magnesium* forms with *silicon*. The answers frequently included the statement that they had never used or studied the substances.

Another cause of a one-sided knowledge of chemistry is occasionally met in students who have had a detailed drill on some comparatively unimportant topic. This is usually in the teacher's own special field of interest, and a thing that he is most competent to teach. A student's notebook sometimes shows the influence of an organic chemist in the large number of organic equations and processes, of an industrial chemist in the emphasis that is put upon such things as soaps, dyes, explosives, etc. I even remember one student who could write practically no chemical formulas, and yet he had studied osmotic pressure until he attempted to apply it to all doubtful points, and another who considered alloys the most important subject in elementary chemistry. Any teacher of chemistry must have some particular hobby to keep alive his interest in the science, but this can be persistently inflicted on an entire class of beginners only at the sacrifice of more fundamental topics. But there are sure to be some bright students in the class who can be assigned outside reading or special laboratory work in some particular field and the results will be very encouraging to them and to the teacher.

Apart from these more or less exceptional deficiencies noticed in the chemical training of some students is the universal difficulty with chemical arithmetic which we must all face. It is a new application of arithmetic that requires constant repetition

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and individual instruction before a student can recognize that it is not a new branch of mathematics. And, after a student has gotten to the point where he can apply mathematical reasoning to chemical problems, we are never sure that his arithmetic will enable him to carry out operations involving such simple things as decimal fractions, percentages, or proportions.

Summing up these and other defects in a student's knowledge of chemistry is an easy matter. As often as not they are due to his dislike of the subject or a mental inability to grasp the ideas of a science that demands clear reasoning and careful observation. And there is no remedy that any high school or college can use to correct this. But the outlook for chemistry is brighter than ever before, and it is becoming more and more popular over the country. This popularity is due, to some extent, to the remarkable advertisement given to chemical products and chemists at the outbreak of the war. Fathers, formerly unfamiliar with college curricula, are reading of chemistry in their daily papers and advising their sons to take it throughout their college course. Aside from any possible effect on our advanced courses, this popularity will certainly have its influence on elementary chemistry in high schools and colleges; it will gradually result in a readjustment of courses, the addition of new equipment, and the raising of standards. And it is to be hoped that more colleges will be in a position to give credit to high school chemistry and that the quality of work done by the high schools will continue to improve.

EXTENSION AGRICULTURAL WORK EXPANDED.

Full development of the plans for further wartime expansion of the extension service of the United States Department of Agriculture will mean at least one demonstration agent—possibly two, a man and a woman—in nearly every agricultural county in the nation and a woman in each of the large cities to give advice on production, conservation, and utilization of food products. This is a statement in the annual report of the Secretary of Agriculture, David F. Houston.

Through provisions in the food production act for development of the extension service more than 1,600 emergency demonstration agents had been appointed by the end of October, making a total of approximately 5,000 cooperative extension workers. Nearly 750 additional counties are cooperating with the department under the food production act in employing county agents. Men county agents total now about 2,000, many district agents are supervising their activities, and about 1,300 women home demonstration agents are at work. These agents not only are performing the normal and emergency demonstration and educational work but also are assisting in other special Governmental activities, such as the Liberty Loan and food conservation campaigns.

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A UNIT COURSE IN ECONOMIC GEOGRAPHY FOR THE HIGH SCHOOL.[1]

By J. PAUL GOODE,
University of Chicago.

Three events loom large in the history of geography in America in the past century. One was the arrival in America seventy-two years ago of the Swiss geographer, Arnold Henry Guyot, who brought with him the wide horizon of the real geographer, the kindly human interest which is the geographer's greatest asset, and an inspiration for scientific analysis, hunting out the fundamental physical influences at work on life, and conditioning life at every turn.

A second event of great significance was the appointment in the early nineties of a committee of the N. E. A. consisting of Davis, King and Collie, who reported out the argument for the new American study of physiography.

The third event of moment was the publication in England, in 1889, of a volume on Commercial Geography by George G. Chisholm.

The work of Guyot gave scientific organization to geography. We had our science expressing itself in the formal divisions, mathematical, physical and political. And then the fascinating development of physical geography began, the livest and most broadening subject taught in the schools a generation ago.

Then came the specialists in geology, and transformed physical geography, a subject which had been throbbing with life interest, into a narrow, lifeless geometry of three dimensions, applied to land forms—a chapter in geology, and to a large extent renegade to geography.

Chisholm, however, chose an angle of the horizon packed with human interest, and strove, as Guyot had done, to find the fundamental physical factors, the geographic influences, at work in the broad field of commerce. And we in America borrowed his work bodily. He had made an octavo volume of about 700 pages, filled with detail. He dealt with the geographic influences at work; then he discussed all the important commodities of commerce; then he presented a study of all the commercial countries. Within two years Cyrus C. Adams brought out the first American text in commercial geography, and in a smaller format, in 500 pages, he went over the same ground as Chisholm, giving us conditions, commodities and countries—omitting nothing.

[1]Read at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Columbus, Ohio, Dec. 1, 1917.

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This text of Adams was a godsend. It gave an opportunity for a host of earnest teachers to bring into the curriculum a subject with limitless possibilities of interest, applying the scientific method in the interpretation of everyday matters of industry and trade. Not that the text *gave* this interpretation. It gave masses of fact, and the teacher and student brought to bear whatever genius they may have had in making geographic interpretations. But the very mass of fact implied in 500 pages treating all commodities and all lands has proved a great handicap. Condensing all this material into so small a space, and rushing over it in a unit course, has of necessity reduced the work of the student to so rapid a scanning of many things as to leave small chance of getting fundamentals firmly planted in memory, or to achieve any particular ease of mind in the thinking out of causal relations. The success of the Adams text and the recognized value of this phase of geography as an element in education have produced in this country a string of texts: Redway, 1903; Trotter, 1903; MacFarlane, 1905; Gannett, Garrison, and Houston, 1905; Gregory, Keller and Bishop, 1910; Robinson, 1910; Brigham, 1911; J. Russell Smith, 1914; McFarlane, J. (University of Manchester), 1914 (?); Dryer, 1916; J. Russell Smith, 1917.

These texts all show a strong family resemblance. To the latest one of them the Chisholm features are plainly still with us. But the variations in emphasis, one from another, show a recognition of the difficulties we are discussing. MacFarlane (1905) gave himself some freedom in discussing certain crops and other commodities of vegetable origin, making that part of his composition less dry, less like a catalog of things. That was because he was first a botanist, and brought to his composition a mind full of the lore of plants, and with a lively interest in plant life. Keller and Bishop (1910) gave rein to the discussion of the human element, doing their part of their three-cornered text most suggestively. Robinson (1910) and Brigham (1911) began to amplify the discussion of certain crops, and other topics. While J. Russell Smith permitted himself pages enough to get quite away from the dry as dust textbook composition and make a discussion which is interesting reading even for the man in the street. But this freedom made a book too large and expensive for the audience he wished to serve, and the condensed version (1917) has with it still the great handicap of too large a field.

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After many years of teaching in this special field of geography, and striving always to delimit the scope of the subject so that one may, by earnest effort, in the course of a lifetime acquire something akin to an "easy mind" in the subject, I have come to a positive conviction that our error has always been one of uncurbed ambition. We have been greedy in trying to do the whole world of things at once. We have been like the boy in the fable who reached into the jar and took so many nuts he could not remove his hand. In the slang of the countryside, "we have bit off more than we could chaw."

Why not then face the difficulty boldly. Let us limit our scope to a field we can cover. Let us establish standards in subject matter and methods of presentation. Let us be brave enough to undertake only what can be covered thoroughly, with time enough to fix in the mind of the student the principles of geographic interpretation. If it shall turn out that more time in the curriculum must be given to geography, let us not worry; let us go to it, and demand the place in the curriculum the subject requires.

I would have in every high school at least three unit courses in geography: I. The Elements of Geography. II. Economic Geography. III. Commercial Countries.

In every junior high school the first of these courses, I. "The Elements of Geography," should be given. This course should give a general view of the physical factors at work upon mankind. This may well be a ground work upon which all later courses in geography and history may be based. It should be required of every student.

The second of the courses mentioned above, "Economic Geography," is the one of largest present interest, and is the part of the geographic horizon to which I wish to invite most careful attention at this time. Its proper place is in the senior high school. In economic geography I would discuss two groups of topics: A. The Commodities of Commerce. B. The Geography of Trade. This calls for a recognition of the entire list of geographic influences, acting as they may act, anywhere in the world, in the production and movement of a given commodity. This establishes a wide view of world relations, and gives a good preparation for the study, in the following course, of a country or a region, as an industrial, or commercial, or national unity. Let us set down here a more detailed outline of this important course:

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II. Economic Geography.

A. The Chief Commodities of Commerce:
   1. The products of the forest:
      Lumber, rubber and other gums, naval stores, cork, drugs, etc.
   2. Products of hunting and fishing.
   3. The products of the grazing lands:
      Wool, hides, meats.
   4. Products of the farm, orchard, and garden:
      The cereals: wheat, corn, rice, rye, oats, barley, etc.
      Sugar cane, sugar beet, potatoes and other root crops.
      Fruits of tropic and temperate lands.
      Vegetables, and varied crops.
      Dairy products, hides, wool, meat.
   5. Products of mines, quarries, wells:
      The mineral fuels: coal, petroleum, gas.
      The metals: iron, copper, lead, zinc, mercury.
      The precious metals: gold, silver, platinum, etc.
      Building stones, cement, precious stones.
      Clay products.
   6. Products of factories:
      Foods and beverages.
      Textiles, leather goods, clothing.
      Paper and other manufactures of wood.
      Machinery and metal wares.
      Chemical manufactures.

B. The Geography of Trade.
   1. Advantage of position with reference to trade, e. g.:
      Advantage of Western Europe, opposite Eastern America, and close by.
      Advantage of Europe in trade with Africa and India.
      Advantage of United States in Western South America, and the Orient, etc.
   2. Development of great land routes of trade:
      The great highways of Europe and Asia, of North America, etc.
   3. The great ocean routes:
      The highway of the North Atlantic, of the Mediterranean, of the Orient, of Panama, and the Great Circle Routes.
   4. The organization of ocean commerce:
      Tramp and liner.
      Shipping trusts, government participation.
   5. The development of market centers:
      Great general, and transshipment points.
      Markets of special commodities:
         Wheat and cotton at Liverpool.
         Wool, tea, diamonds, at London.
         Coffee at New York.
         Bananas at New Orleans, etc.

The scope outlined above is amply big for a unit course. There is no subject in the curriculum which offers a better opportunity than this course does, for training the logical faculty, or for widening the horizon of the student in matters of everyday interest in the world about him. It is a liberal education in itself.

As an illustration of the method of study, showing the thought-provoking possibilities of the subject, let us indicate the subtopics in the study of one of the cereals, say:

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Wheat:

1. Plant characters of wheat, and our knowledge of its origin.
2. Climate and soil required.
3. Types and qualities of wheat as related to climate and soil.
4. World's wheat producing areas, and reasons for location and importance.
5. Influence in production, of surface, labor conditions, use of machinery, transportation facilities, skill of the farmer.
6. Problems of milling, marketing, establishment of the world market center, and the method of making the price.
7. Wheat in international commerce and politics.
8. The problem of the wheat supply of the future.

In every stage of this discussion the teacher is on guard that the *geographic influences* are being discussed. The criterion of any point discussed must be as to whether it is, or has, a geographic influence. This discussion of wheat goes down to the roots of things for many influences at work in Britain and Germany, and in the United States of America and other newer, wheat producing lands. It calls for some knowledge of historical development in all the lands in the world whose people must buy wheat, or who have wheat to sell.

Or suppose we take the topic sugar, we should have:

Sugar:

1. Historical sketch of the rise of sugar.
2. Plant characters of cane.
3. Climate and soil required for cane.
4. World's producing areas, as related to climate, soil, labor, transportation and market facilities.
5. A survey of the farmer's problems—planting, cultivation, harvesting, preparation, marketing.
6. Historical sketch of the rise of the beet.
7. Changes in character of plant under domestication.
8. Soil and climate required.
9. Beet areas in Europe and America.
10. Rise of the beet in America.
11. Sugar refining, and marketing the final product; location of refineries.
12. Uses of sugar: their influence on commerce.
13. Output of sugar by the important producing regions.
14. Government interest in the sugar industry in Europe and America.
15. The future of the sugar supply.

Here again one must open the question of tropical versus temperate agriculture and labor conditions. Must look into the almost unbelievable complications, economic and geographic, following a settled government policy in Germany of fostering the production of beet sugar. Political relations between Britain and Germany, and between Britain and her colonies—as well as unsuspected economic influences in our American attitude toward "Imperialism."

Or suppose the topic is the most important metal, iron, we must inquire as to:

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Iron:

1. The qualities which make iron and steel valuable.
2. The significance of iron in the civilization of the race.
3. Chief iron producing regions of the world.
4. Methods of winning the ore: in Minnesota, in Sweden, in Spain, etc.
5. Problems in transportation of the ore—the question of limestone and coke.
6. The phosphorus question, and steel making processes.
7. Present rank of regions producing iron and steel: a geographic interpretation of their relative importance.
8. The price of steel since 1850, and the significance in industry and trade of cheap steel.
9. The trust control and the development of government interest in steel manufacture.
10. Estimates of the world's total stock of ore and the significance of the location of the ore bodies.

It may be observed that the study is avowedly economic, as well as geographic, and geographic and economic influences underlying industry, commerce and human welfare are sought in every stage of the study. This makes of the subject a fascinating field for both teacher and student, and it has the superlative advantage of continual growth, of eternal youth. It is quite unlike a paradigm, or a table of constants, calling for memory only. It calls for an alert mind, a mind that takes delight in searching out the causes which explain the intensely interesting and endlessly moving phenomena of the world about us.

Let us now mention the logical successor to the course in economic geography, a course which makes a somewhat careful geographic interpretation of the commerce of some of the leading commercial countries. Let's call it

III. Commercial Countries—a course which should come as late as possible in the senior high school.

The point of view is now avowedly regional. The unit is the country. And again we run the gamut of physical influences, acting now in a given region, and getting certain responses in industry, transportation, and the segregation and occupations of the people. Now all we have learned of the influences at work in the location and development of commodities may be used as material for clear thinking in the present status and stage of industrial development of a country. We shall find here an interest in a *people* and their place in the world.

There should be no attempt to discuss all countries. Important countries should be chosen and studied as to commercial development and possibilities.

We may begin with a statement of the rapid growth of world trade in recent decades, and take for our task the geographic interpretation of this marvelous development.

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We shall want to know what leading countries have been most conspicuously active in this development, and in what particular lines of development, industrial and commercial, these nations have been conspicuous. We shall look for the trend of commerce in the leading commodities exported and imported through the decades, and be able to account for the changes in the rank of these commodities; for the dying out of some lines and the rise of new lines to a prominent position.

Then we must analyze the trade to show the international relations, the trend of trade through the decades with the countries of largest intercourse—and be able to find in the facts we deal with the reasons for these changes.

First of all the countries studied, should be our own. And we should compare it with some young tropical country, say Brazil. Then Britain, an old nation, might be studied in similar fashion and compared with the United States of America as a young nation, and with India as an old tropical nation. Germany in turn may be taken up and studied in contrast to Russia, and possibly with Argentina, to bring out the surprising contrasts. France and Australia, for contrasts of old and young, and with Japan and China for another phase of development of old countries, presenting phenomenal signs of rejuvenescence.

The opportunities for development in such a course are endless. It is a course as live and as recent as the evening paper. Though the principles of the subject may be rooted in the very nature of things, its data are in continual flux with the everyday changes in the weather, the changes of market conditions, and the continual shifting of international political relations.

For these reasons it is not an easy study to prepare in or to teach. The materials are all around us in every business we may look into. There is a continual incentive to follow developments in such periodicals as the *World's Work*, *The Nation's Business*, and the more technical trade magazines. Especially fortunate are we in our government, which in special monographs in many fields is publishing, at no cost to us, the finest material obtainable. The daily *Commerce Reports* are invaluable. The special reports of consuls and trade experts put the richest storehouses of material into our hands. Even the daily papers have grist for our mill, and just in proportion as we are properly educated the space devoted to scandal and gossip in the press will decrease.

No course has such a wealth of potential graphic material

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waiting for it. Graphic statistics become eloquent. Maps of every sort have tremendous possibilities in presenting our subject matter. An atlas should be in every student's hand. Unfortunately, there is no atlas in existence that really meets our needs.

No subject could be more significantly aided by pictures. These three courses could with profit use a thousand typical pictures. As photographs, as lantern slides, best of all as stereographs, they may be made strongly to reinforce the text or class discussion. Even the "movies" occasionally, as it were by accident, give us valuable educational films. I fondly hope the time may come when such courses may be equipped with moving picture machines and libraries of films.

This entire subject, properly presented, is not merely three unit courses or three years of high school work. It is rather an inoculation of intellectual good health which will last through life. The reward of such a study is found in the exhilaration of a constantly widening horizon, and of a migration out of a provincial frame of mind into an atmosphere of serious, worthy cosmopolitan interests.

LABORATORY EFFICIENCY.

By H. R. Smith,
Lake View High School, Chicago.

In no occupation is there more need to heed the war-time exhortations of "prevent waste and lost motion" than in that of teaching. Of all teachers, the science teachers are likely to feel that they are the most efficient. Yet, laboratory methods may be as formal and "dead" as any others.

Laboratories are equipped with the idea of giving students real experience. Yet in many cases chemistry teaching at present is nothing more for the students than mental excursions radiating from the class textbook, rather than mental excursions from real basic facts. Few teachers outline a practical course in chemistry for their students. Chemistry is generally taken as it comes from a book rather than as it comes in life.

If laboratory work is to bring the results desired, namely: training in observation and reasoning, and stimulation of interest, it must be *initiated* in the laboratory. Perhaps the laboratory work does go better if the textbook is studied first. But the main reason for this is that most students will gladly

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allow the textbook to do their thinking for them, while they perform only the mechanical operations of handling the materials and copying notes from the book. It does not seem wise to offer training to our students that will do no more than make them compete with labor-saving machinery for a job.

Preparation for laboratory work should be that which will reveal the purpose of the experiment, and at the same time afford such a grasp of conditions and procedure as to make the experiment a mental as well as a physical exercise. If results and explanations are known previous to the performance of the experiment, then it becomes a waste of time and materials. If this plan is used it will easily be possible to find certain members in every class who record results *not as they actually happened* but as they were said to happen in the textbook. Such work is mere sham, and demoralizing to the student. The proper function of our textbooks in chemistry, as they are now constituted, is to correct and amplify student deductions from experimental facts, and supply information not readily available by experiment.

With the belief that laboratory work was not furnishing the desired results, the instructors of chemistry in the Lake View and Nicholas Senn Schools, Chicago, combined efforts over four years ago to improve it. Their results have been obtained by trial and elimination of methods in classes totalling over a thousand students to date. Their joint findings are herewith presented for the cause of better chemistry teaching. The positively good results they have obtained are not conditioned by local or variable factors but rest upon broad general principles that may be applied by any teacher who wills to do so.

Regarding the textbook as an improper source of preparation for laboratory work, introductions of about one printed page for each experiment were prepared. They contain points of historical and general interest, examples which typify the "scientific method of study," a working mental start on the chemical action involved, and the specific purpose of the experiment. The introduction and experiment sheets are given out to students the day previous to the laboratory work. Each student is required to present evidence of preparation by exhibiting a written statement of the purpose of the experiment on the sheet of it to be used as a record before the student is permitted to perform the work.

Since the loose sheets permit final binding of the direction

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sheet with the record sheet, no attempt is made to record the procedure of the experiment. Each student records results only in final form as the work is performed, having section numbers corresponding to those on the direction sheet. Students that are addicted to the "copy" habit are inclined to demur at this requirement, but after a thorough trial they prefer the new way. The direction sheets contain questions which involve the use of the recorded experimental data. They serve to emphasize the main points of the experiment.

At the close of the laboratory period all record sheets are deposited with the instructor. The student retains the printed sheets and studies them, using the text in preparation for the next recitation day. At this time the record sheets are returned after a cursory inspection by the instructor. During recitation the records are corrected by students, preferably with pencil or ink of different color, and presented to the instructor for final approval and credit. The students are given to understand that they will be discredited for *not correcting mistakes* rather than making them.

A sample experiment with student record may be found on the following pages.

DISCOVERIES.

In all manufacturing operations there are waste products which are likely to be discarded with little attention because of their seeming worthlessness. Soap makers formerly allowed tons of glycerin to flow from the boiling tanks into the sewer because they did not know its value. Instead of paying thousands of dollars annually for the removal of its garbage, a certain eastern city receives a bonus of $600 per day from a company of thrifty men who collect the garbage and extract products of value from it. A chemist in a government mint had a suspicion that valuable metals were allowed to escape in the process of refining silver and gold. He began an investigation and found that thousands of dollars' worth of platinum was going to waste every month.

In 1826, while Balard was studying the composition of the waste liquor after crystallizing the salt out of the water from salt marshes, he obtained a dark brown liquid having an unpleasant odor. He called it "muride" because of its source, but later changed it to "bromin" because of its bad odor. By this study of a waste product a new element was discovered for the use of men. An opportunity to discover the element, bromin, was offered to Justus von Liebig. Some years before Balard's discovery a salt company sent him a jar of liquid containing much bromin, and requested him to examine it. After a casual study of it he believed it to be iodin chlorid. After Balard's discovery Liebig saw the mistake which he had made by relying on preconceived ideas and not on experimental facts. He placed the jar in a special cabinet for storing mistakes—"l'armoire des fautes," as he called it. Balard became famous by his discovery of the element, bromin. His inferences and conclusions were based on facts that he had obtained directly from nature by experiment. He used what is called the scientific method.

Near Stassfurt, Germany, much "Abraumsalz" (refuse salts) were thrown aside in the process of mining rock salt. Two chemists, Rose and Rammelsberg, made a study of it and found that it contained much potassium and magnesium. Today these mines are worked for the salts

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of these metals and the sodium chlorid has become the by-product. The "Stassfurt Salts" constitute one of Germany's richest natural resources. The world's chief supply of bromin and potassium are obtained from these salts.

BROMIN.

Experiment.

Purpose.—State it on the separate sheet used for record.
Apparatus.—15 cm. test tubes with a one-hole cork stopper to fit; L tube; stirring rod.
Materials.—Concentrated sulfuric acid, potassium bromid, powdered manganese dioxid, carbon disulfid, starch.

I. **Preparation:**

Bore a hole through a cork that has been fitted to a 15 cm. tube and insert the short arm of the L tube in the hole. Mix several medium sized crystals, or 1 cc. powdered crystals, with twice its bulk of powdered manganese dioxid and put it in the 15 cm. tube. Adjust the clamp to hold the tube in a slanting position and fill another tube two-thirds full of cold water. Pour 2 cc. of concentrated sulfuric acid into 1 cc. of water and cool it. Then pour it upon the dry mixture in the other tube, insert the cork with L tube, and hold the tube of cold water so that the long arm of the L tube will dip **just below** the surface of the water. Heat the mixture **slowly** and **constantly** with a medium flame until the reddish vapor is driven beyond the bend in the L tube. Do not heat enough to boil the black liquid through the L tube nor stop heating until all the red vapor is driven over. Then stop heating and remove the tube of water **at once.** The dark liquid in the bottom of the tube is bromin. Describe the action in the generator during the preparation. (?) Diagram the apparatus and label the parts. Write the equation and balance it. The molecule of bromin has two atoms.

$$?KBr + MnO_2 + ?H_2SO_4 \rightarrow KHSO_4 + MnSO_4 + ? + ?$$

II. **Properties:**

(a) The colored water above the bromin in the tube is called "bromin water." Pour 2 cc. of it into a 10 cm. tube, add 1 cc. (no more) of carbon disulfid, cover the tube with thumb and shake it. Most of the disulfid settles to the bottom. Compare the colors of disulfid and water, which show the relative solubilities of bromin in the two liquids. (?)

(b) Wet a stirring rod and roll it in dry powdered starch. Heat a drop or two of bromin liquid and hold the rod with starch in the vapor of bromin. (?) This effect is used as a test for bromin.

(c) Test bromin water with both colors of litmus. (?) Pour some on a little cochineal solution. (?) Note the effect of the bromin on the cork used in the generator. (?) Pour any liquid bromin remaining after tests into the stock bottle of bromin water.

(d) Tabulate the physical and chemical properties of bromin. Give the degree of solubility.

BROMIN.

Experiment 35, Dorothy Borg.

Purpose.—To prepare and study the properties of bromin.

I. **Preparation:**

$$2KBr + MnO_2 + 3H_2SO_4 \rightarrow 2KHSO_4 + MnSO_4 + 2H_2O + Br_2$$

The substance in the generator has a very dark brown color which, when heated, turns a reddish brown. The heat applied forces the reddish vapor through the L tube into the water forming bromin water. Bromin settles in the bottom of the tube.

II. **Properties:**

a. The disulfid is colored much more than the water.
b. Bromin colors starch brown.
c. Bromin water colors litmus paper red and bleaches it.
d.

Physical	Chemical
1. Color—dark red liquid.	1. Bromin turns starch a brown color.
2. Odor—very sharp and disagreeable.	2. Bromin water is an acid because it turns blue litmus paper red.

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3. Sp. gr.—heavier than water.	3. It bleaches calico but does not act as vigorously as chlorin.
4. Solubility—less in water than in carbon disulfid.	4. It attacks cork.

The methods mentioned give satisfactory results on the following points:

1. The introduction to experiments gives a working knowledge of the problems involved in the experiment.

2. Training in accurate observation is secured by making the permanent record in the laboratory *at the time the results are obtained.*

3. The thinking out and writing of record is done at the time and in the place in which the student can have individual instruction from the teacher.

4. The loose leaf experiment sheets placed with the student's record sheets makes a suitable permanent record without any copying of procedure by the student.

5. The loose leaf plan saves time and paper for the student.

6. The loose leaf plan eliminates the drudgery of handling piles of student note books.

7. The loose leaf plan permits collection of student records each day without taking away the assignment for the following day.

8. The loose leaf plan permits carrying student records easily anywhere to be read and graded during the teacher's unoccupied time.

9. The loose leaf plan permits insertion of practical experiments of local interest.

10. Students correct their own mistakes under the supervision of teacher during the following recitation period.

11. The removal of the temptation to unfair practices in doing work promotes general honesty.

12. The study of chemistry is more comprehensible when experiments are grouped under larger heads.

13. The knowledge in the results is developed by the questions to be answered by the student.

14. Library and extra work is systematically developed as optional work.

Price of Preprints of the "Status of Mathematics in Secondary Schools."

Preprints of this article, published in the January, February, March and April issues, may be had for 10 cents from Mr. M. J. Newell, High School, Evanston, Ill., or from Mr. Alfred Davis, William and Mary College, Williamsburg, Va.

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THE REORGANIZATION OF HIGH SCHOOL SCIENCE.

FRED D. BARBER,
Illinois State Normal University, Normal, Ill.

The day has passed when it was pertinent to ask whether high school science needs reorganization; high school science is now being reorganized. While this reorganization has been taking place some of our scientific friends have been so engrossed in the daily routine of teaching science that they have had no time to glance over their spectacles and note the condition towards which high school science is rapidly drifting. Other of our scientific friends, more alert, have seen with unwilling eyes the drift of science but they have held firmly to the traditions of their own high school and college days; they have rebelled against every innovation; they have contended that the charge that much of our high school science teaching is a near failure from the point of view of the boy or girl is heretical and should be suppressed; they have compared those educators who asked that high school science be reorganized to the boy who cried "Wolf" when there was no wolf; they have said: "Leave high school science alone; we admit that the drift is bad at the present, but the organization and subject matter is the best possible; college and university men approve of it; apparent defects are due to poor teaching and we are about to remedy that defect."

This *laissez faire* attitude has been most pronounced in teachers of the biological and earth sciences; teachers of physical science have, as a rule, taken more kindly to the demand that high school science be modified, that it be adapted to the interests of high school pupils and to the needs of modern life.

Generally speaking, physical geography, physiology, zoology and botany have been the sciences taught in the first two years of the high school course. The *laissez faire* attitude of the teachers of these subjects, coupled with the growing conviction that the reorganization of high school science must begin at the bottom of the high school science curriculum, is now leading rapidly to the elimination of these subjects from the high school curriculum and the substitution of other subjects which are believed by many to be better adapted to the needs and interests of the pupils in the early years of the high school. The extent to which these four science subjects have declined during the past fifteen years—especially during the past five years—will be seen by a study of the accompanying graphs and Table I.

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TABLE I.

Table showing per cent increase (bold face) or decrease (light face) during the five years from 1910 to 1915 in the *percentage enrollment* in the high school science subjects.

Subject	United States	Iowa	Wisconsin	Illinois	Ohio
Physics	3%	4%	17%	4%	10%
Chemistry	7%	15%	4%	3%	8%
Physical Geography	25%	35%	33%	24%	18%
Physiology	38%	31%	30%	8%	44%
Botany	45%	39%	30%	17%	28%
Zoology	59%	54%	50%	22%	49%
Agriculture	**54%**	**513%**	**24%**	**52%**	**231%**
Domestic Economy	**241%**	**593%**	**237%**	**65%**	**340%**

From these data it appears that physics is now nearly holding its own, that chemistry is making slight gains, that physical geography, physiology, botany and zoology are all rapidly losing ground and will soon disappear as high school subjects, or at least they will soon become unimportant subjects in the high school curriculum. It also appears that agriculture and domestic economy are everywhere making rapid gains. It is unfortunate that the reports of the Commissioner of Education, from which these figures are taken, do not show the part which general science is taking in this realignment of high school science.[1]

It is interesting to note the approximate date at which we may expect physical geography, physiology, botany and zoology to disappear, or practically disappear, from the high school curriculum if their decline continues at the rate indicated from 1910 to 1915.

TABLE II.

Table showing approximate date at which the science subjects generally taught during the first two years of the high school curriculum may be expected practically to disappear, their places being taken by other subjects.

Subject	United States	Iowa	Wisconsin	Illinois	Ohio
Physical Geography	1930	1924	1925	1931	1937
Physiology	1923	1926	1927	1965	1920
Botany	1921	1923	1927	1939	1928
Zoology	1919	1919	1920	1933	1921

It would probably be erroneous to conclude, however, that high school science as a whole is at the present time declining

[1]The High School Supervisor of West Virginia in his report for 1915-1916 gives the total enrollment in high school science subjects in that state as follows: Physics, 831; Chemistry, 992; Botany, 738; Agriculture, 1431; Biology, 2194; and General Science, 1133.

A report of the Committee on Science in the High School of Tomorrow, given before the Central Association of Science and Mathematics Teachers, at Columbus, Ohio, November 30, 1917, shows in thirty-six large high schools in the Upper Mississippi Valley, having a total enrollment of 42,107 students, the following percentage enrollment in the sciences: Chemistry, 10.5 %; Physics, 10%; Botany, 4.9%; Zoology, 2.3%; General Science, 7.1%; Physiography, 5.4%; Physiology, 2.5%.

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if we include as high school science agriculture, domestic economy, general science and general biology. A study of the reports of the Commissioner of Education for the past twenty years, incomplete though the reports are, leads to the conclusion that the total percentage enrollment in high school science subjects did decline from about 1900 to 1910 but from 1910 to 1915 there was a slight increase.

An analysis of the nature and significance of these shifts in our high school science curriculum is important. It seems fair to presume that, in a large measure, physical geography and physiology have given place to general science as the first-year-science course. Likewise, it is apparent that botany and zoology have given place to general biology in many schools in certain states and to agriculture in many schools in many states. Domestic economy, without doubt, has displaced the older sciences in many cases.

Why were these shifts made? Was it mere caprice, a desire on the part of teacher or pupil, or both, to try something new or different? Or is there a deep-lying conviction held by superintendents, principals, science teachers, and educators in general that the science courses which have been generally offered during the first two years of the high school curriculum are not well adapted to that purpose?

The accompanying graphs show that for some years before the advent of agriculture, domestic economy, and general science, all of the old recognized sciences were suffering a rather rapid decline. The truth is that all of the old recognized sciences failed some years ago to command the respect of students of education when regarded as educative materials which would best equip the pupil to take his place as a prosperous and self-respecting citizen in this twentieth-century world.

The following five graphs show the percentage of the total number of the public high schools of the United States and in Iowa, Wisconsin, Illinois, and Ohio which were enrolled in the various subjects indicated in 1900, 1905, 1910 and 1915.[2]

In a measure, teachers and textbook writers of the physical sciences began to recognize the defects in the methods and

[2]Note: The data from which these graphs were made are to be found as follows:
Summary for the United States from 1890 to 1915, p. 487, Vol. 2, Report of the Commissioner of Education for 1916.
For the various states for 1900, pp. 2138-2139, Vol. 2, Report of Commissioner of Education for 1899-1900.
For the various states for 1905, pp. 832-833, Vol. 2, Report for 1905.
For the various states for 1910, pp. 1182-1184, Vol. 2, Report for 1910.
For the various states for 1915, pp. 500-503, Vol. 2, Report for 1916.

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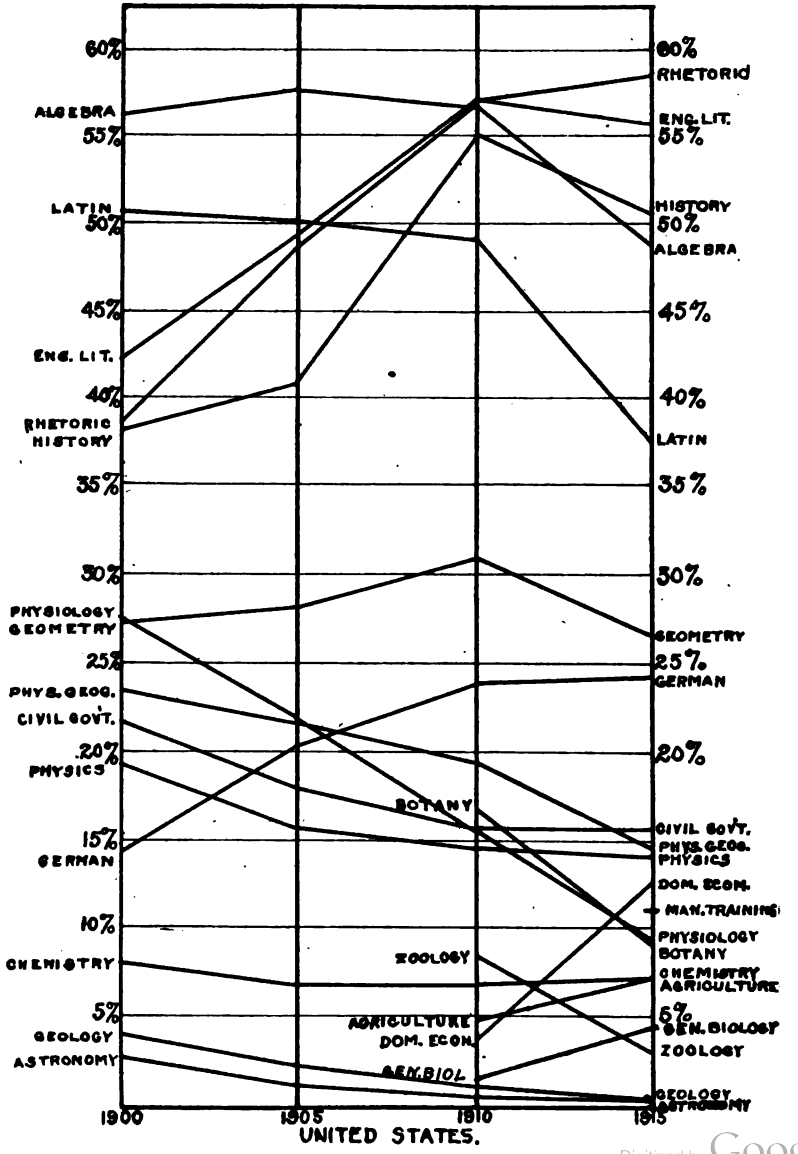
materials of high school physics and chemistry some years ago. Some of the recent textbooks and considerable of the teaching bear evidence of a conscientious effort to make these courses more practical, more worth while and more interesting to the pupil. While there is unlimited room for further improvement, yet the changes already effected have been partly responsible for the check in the decline in percentage enrollment in these subjects.



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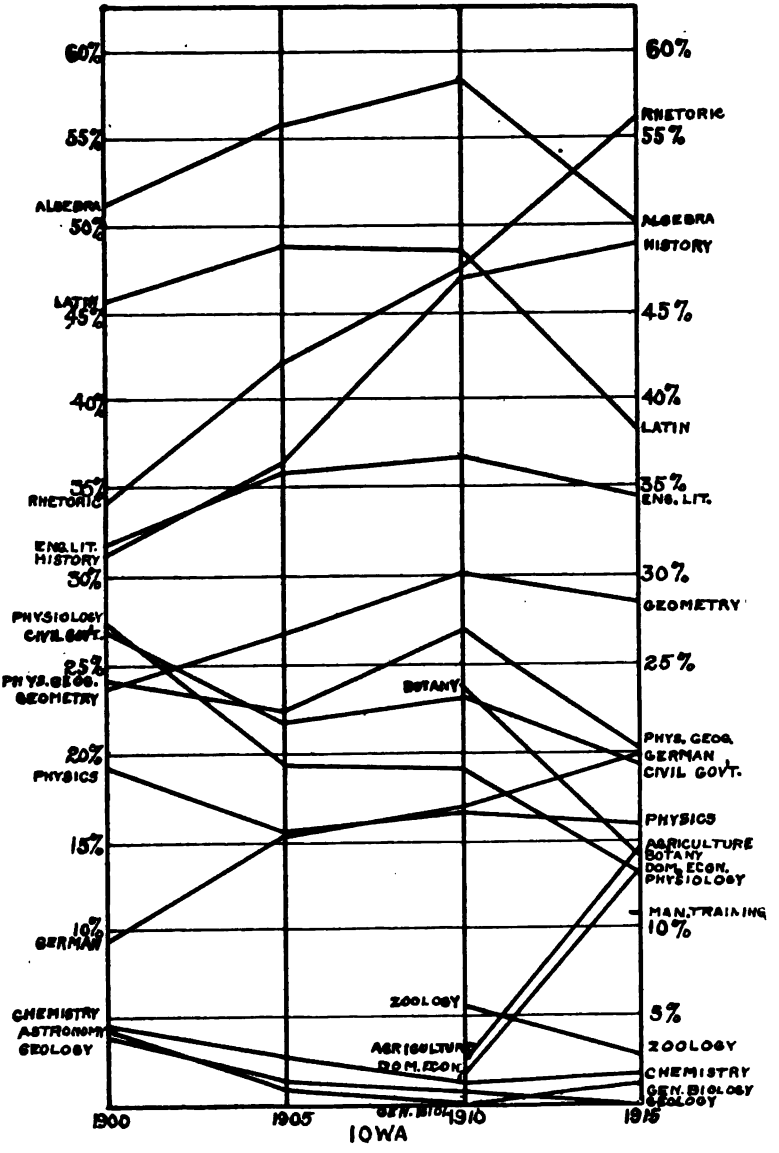
In rather marked contrast with the attitude of the more progressive teachers of the physical sciences is the *laissez faire* attitude of many of the most influential leaders among the teachers of the biological sciences. One has but to study the addresses given at the educational meetings of the past fifteen years, to read the articles contributed to our educational journals, and to compare the resolutions adopted by the various biological



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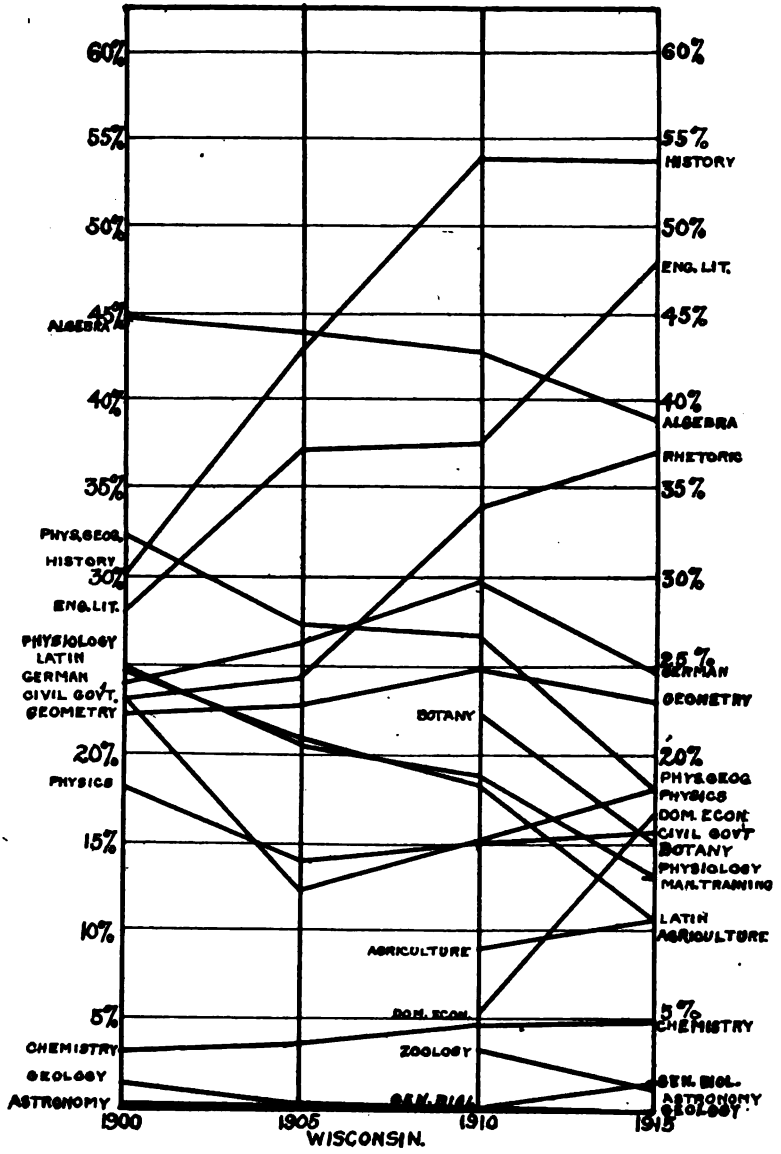
and physical science sections of our educational associations to note clearly this different attitude. There is little doubt that the attitude taken by the teachers of those sciences usually given in the first two years of the high school has been, in a large measure, responsible for the changes now taking place.

If the teachers of physical geography, physiology, botany and zoology, and especially the writers of the texts used, had



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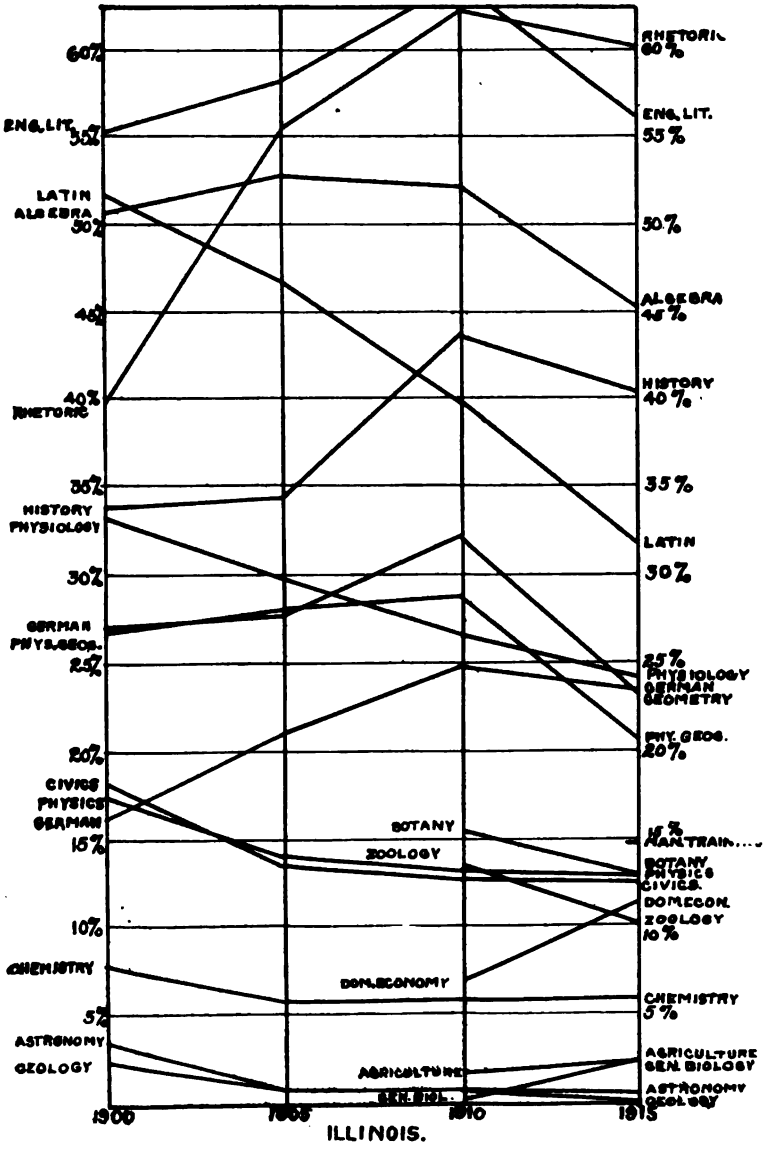
found a way of so modifying those courses some years ago as to make them appeal to the pupils as being more worth while and appeal to superintendents and principals as being of higher educational value, it is doubtful if general science, agriculture and domestic economy would ever have made much progress in displacing them. Many courses offered in agriculture and domestic economy belong in the later years of the



ILLINOIS.

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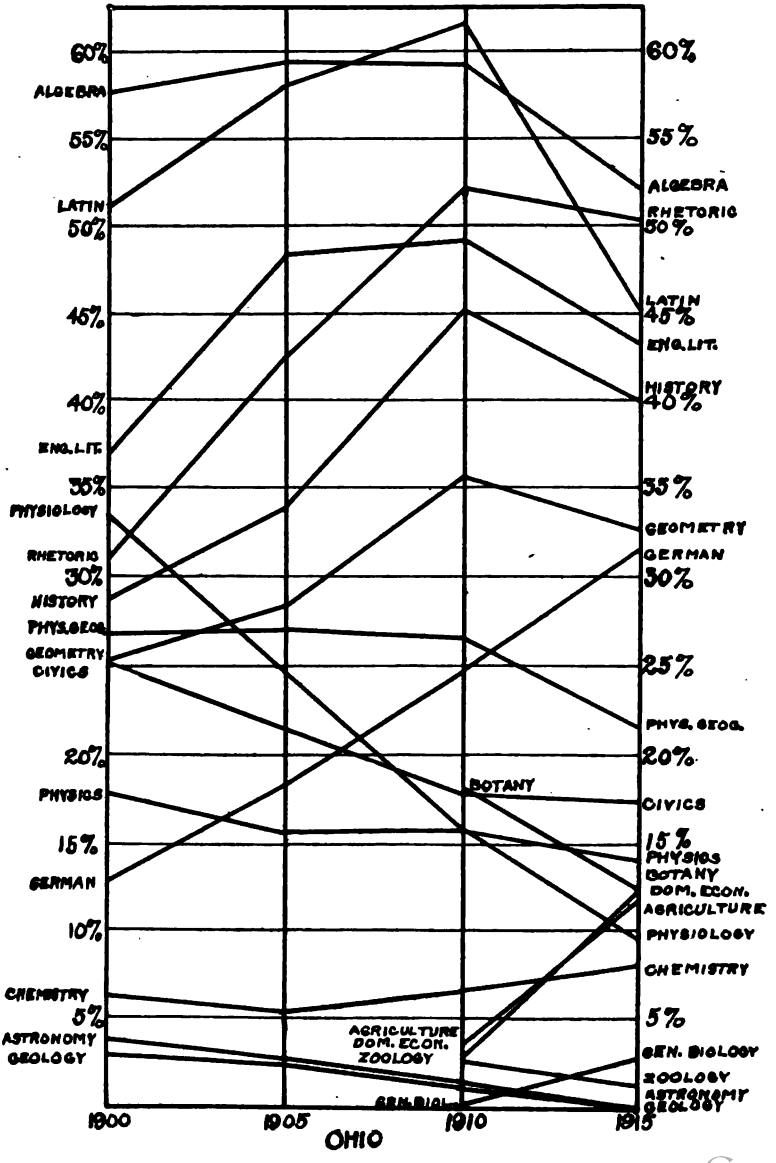
high school curriculum; such courses presuppose a knowledge of certain principles of science. Had the courses offered in the first two years really afforded the proper foundation for the study of agriculture and domestic economy, I am convinced that in our better school systems these two new "applied sciences" would have been placed farther up in the course, presumably displacing physics and chemistry.



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A Condition, not a Theory.

Our scientific friends who have been given to jeering at agriculture, domestic economy and general science as being "near science" and the "offspring of soft pedagogy" are now face to face with a condition, not a theory. Whether we classify these new subjects as science subjects or not, the fact remains that they have come to stay. With the departure of physical geography, physiology, botany and zoology from the curriculum of the high school these new subjects will receive more attention and will be better taught. If these new subjects, as they are at present taught, lack some of the elements which gave to the older subjects greater educational value, it behooves the devotees of "pure science" to bend their best efforts towards helping so to shape up future high school science courses that those elements may be preserved. It is no secret that many students of education who have looked with favor upon the introduction of agriculture and domestic economy into the high school curriculum feel that the *substitution* of these courses, as they are frequently taught, for the old line science courses is a doubtful proceeding.

Nature of the Readjusted High School Science.

In the readjustment of high school science we should endeavor to preserve the best elements to be found in the old regime of special science and incorporate them with the best elements of the new regime of applied science. The old courses were not altogether bad; the new courses are not altogether good. Reorganized high school science should incorporate the elements of worthwhileness and interest from the new courses with some of the breadth of view and much of the scholarly attainment claimed for the old courses. If a course of science instruction extending from the seventh or eighth grade through the twelfth grade can be so organized and so taught as to attain these ends—and there is no apparent reason why this can not be done—then the reorganization of high school science will have been well worth while.

There can be but little question about the older sciences having afforded an insight into the historical significance of science and into the traditional man-made units of human knowledge concerning nature which the applied sciences will never give. It may be debatable whether the older sciences necessarily afforded a better opportunity for mental training, a claim insisted upon by the adherents of "pure science." Possibly it is inevitable

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that a newly organized subject shall lack, to a considerable degree, the conciseness and exactness which characterizes a subject which has been decades if not centuries in developing. It is this element of conciseness and exactness so manifest in the dead languages and in mathematics which gave those subjects for many years the reputation of being of the greatest educational value. Moreover, the teaching of such a static subject largely becomes a matter of imitation. The body of subject matter to be covered is well defined; the method of instruction is largely predetermined; the beginning teacher can do fairly well if he but follow closely in the footsteps of his own teacher. No such slavish imitation will produce acceptable results when applied to a developing, dynamic subject such as agriculture, domestic economy or general science. These subjects are in their formative stage and will remain so for many years to come.

A Danger to be Avoided.

The disrepute into which agriculture and domestic economy have fallen in the eyes of scientists lies in the fact that in a multitude of cases these subjects have assumed chiefly the form of arts, not sciences. To substitute the art of agriculture or the art of cooking for a training in the fundamental principles of science is an educational error which can produce nothing less than a failure quite as serious as the failure of "pure science" in which the principles of science were taught abstracted from all settings of human welfare. The present tendencies to substitute courses in agriculture and domestic economy for all science courses hitherto offered in the first two years of the high school course can result in nothing short of revolt on the part of every educator who appreciates the fact that all progress along material lines rests finally upon a knowledge of the fundamental principles of science. The pendulum in swinging from "pure science" to the art of agriculture or the art of domestic economy has swung far past its normal position and is bound to return.

The proper reorganization of high school science consists in the establishment of a required stem course of science which shall incorporate the elements of historical significance and scholarship from the old regime with the elements of true worth and interest from the new regime. This course should be two years in length; it must deal with materials of universal value; it must present science in its psychological and pedago-

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gical order, not the logical order of special science; it must recognize the natural interests and the point of view of the pupil, not the interests and point of view of the trained scientist; it must afford the necessary foundation for an understanding of the principles involved in the art of agriculture and the art of domestic economy and at the same time it must provide the foundation for the further study of science in the college and university.

The "Ordinary" Four-Year High School.

The "ordinary" four-year high school is impossible of definition. Sometimes there are but two or three teachers; sometimes there are twenty-five or fifty teachers; some of these schools are strictly rural in character; some of them are strictly urban in character. While it is highly desirable that all high schools shall be standardized to the largest possible extent, we must allow rather wide margins in the science courses offered and the sequence in which those courses are taken. It is possible, however, to standardize the science curriculum so far as a *two-year stem course* is involved. The two-year stem course here advocated should be equally applicable to high schools of every type, the two-year high school, the three-year high school, the four-year high school, the rural high school and the urban high school. It will be equally applicable to every type of high school because it must deal with materials of universal interest and importance. The materials dealt with and the fundamental principles taught must be those which have universal application.

Character of the Two-Year Stem Course.

If this stem course in science is to meet the needs of all beginning students: it must meet the needs of the 95 per cent who never expect to go to college; it must meet the needs of the 5 per cent who do expect to go to college; it must meet the needs of the ever increasing percentage who will study agriculture as a preparation for life's work; it must meet the needs of the still more rapidly increasing percentage who will study domestic economy as a preparation for life's work; it must deal with materials which appeal to all high school pupils as being of such vital importance that an abiding interest in the study of science results; it must develop and make clear a large body of scientific principles which should constitute a portion of the equipment of every well educated citizen—the scientific pabulum of an independently thinking people.

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It must not be the end and aim of this stem course to make artisans in agriculture or in domestic economy of all our young people. It must give every pupil a glimpse of the history of the development of science and of scientific achievement at least from colonial days to the present time. They must see something of the influence of science upon the march of civilization. While the practical phases of science as it affects our lives here and now must be prominent in this two-year required course, it must also contain some of the cultural elements to be obtained from a survey of the historic past. Agriculture and domestic economy as they are now generally taught are as impossible of survival as the science to be taught in this stem course as were the old line sciences which are now passing out of the curriculum.

It matters little under what name or title this two-year course is listed; it is of imperative importance that it shall develop the foundation principles of science and do so in such a manner as to enlist the interest of the pupil and lead him into the habit of ever seeking the scientific explanation of common life-experiences. I know of no name or title more appropriate for such a course than to call it a *two-year course in general science.*

No matter under what name this two-year course is listed, its organization must be that of general science and not that of special science. It will be general science because it will disregard the artificial boundaries of special science; it will be general science because its units of instruction will be the natural, Creator-made units and not the artificial, man-made units of special science; it will have the general science organization because the principles taught will arise out of a study of the pupil's environment and not out of a study of types, many of which are entirely foreign to the pupil's present or future environment, as is the case with special science.

As a general plan for organizing the material of one's environment into a two-year course I suggest that a study of the home, the school and the street leading from the home to the school be made the first year; a study of an outer field comprising the animal and plant life found in the garden, in the orchard and in the field, together with such a study of aquatic life as may be available shall comprise the second year's work.

SUGGESTED TWO-YEAR REQUIRED COURSE IN GENERAL SCIENCE.

Naturally, physical science materials, such as lighting and heating systems, refrigeration, water supply and sewage disposal, the use of labor-saving machines, the weather, climate,

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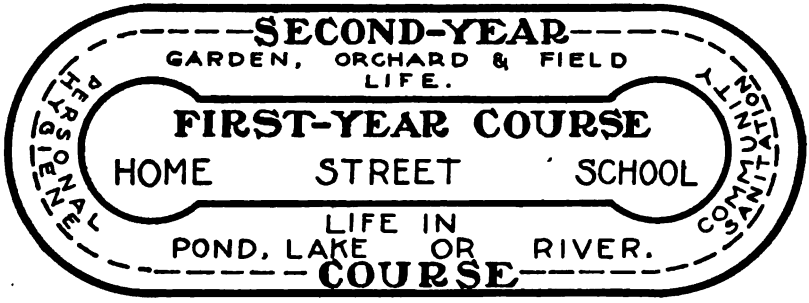
ventilation, together with food and nutrition and microorganisms will comprise the course, and personal and community welfare will be the point of attack. The second course will reach out on every side for materials and will include a study of the plant and animal life found in the outlying environment of the school and community. It should also include a more comprehensive study of personal hygiene and community sanitation. The second year's course will, therefore, deal chiefly with biological materials although the influence of physical environment will everywhere be an important consideration.



Much of the material which it is proposed to use in this two-year stem course is material which might properly be also studied in applied courses in agriculture and domestic economy. The manner of treatment, however, would be quite different from that given either in the old special science courses or in the newer applied science courses where the same material might be studied. For example, suppose that we consider the corn plant as the unite of instruction. In the special science, botany, no such unit of instruction would be tolerated. If corn were mentioned, it would first be mentioned, perhaps, when studying the unit *germination;* next, it might be mentioned many pages later when the unit *roots* was under consideration; its next mention might be under *stems;* thirty or forty pages later it might be mentioned under the unit *leaves;* later it might be mentioned under *flowers;* finally, it might again be mentioned under the unit *fruits and seeds.* Thus the study of this most important cultivated plant (which every pupil should study as a natural unit) is actually fragmentary and disjointed simply because special science refuses to recognize natural, Creator-made units but insists in serving up science in artificial, man-made units.

In agriculture, however, the corn plant and its environment *is* a logical unit because agriculture does deal with the

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natural or Creator-made units. But in applied agriculture the question raised is: How can we so select seed, how prepare the seed bed and cultivate the crop that we can secure more bushels of corn from an acre of land? The study of corn thus becomes more or less a study of the art of corn raising. Of course, the matter of insect pests will necessarily arise and so the study of corn will introduce some study of zoology, as will also the study of the preparation of the seed bed and the cultivation of the corn introduce some study of soil physics and weather and climate. Agriculture is necessarily general science and not special science so far as it is science at all.

In this stem course of general science with which we are now concerned, the purpose is somewhat different and therefore the attack and development is different. Here the question might well be: How does corn serve mankind, and how has it served him in the past? How does it grow? What is its natural environment? The technical and detailed study of producing it more cheaply or in greater abundance or of improving its quality may well be left for development in the course in agriculture; only those phases should be presented in this required course in general science which have to do with an understanding of corn, its nature, its natural environment, its cultivation and its uses—those phases which should be the possession of every well-educated citizen. That the prevailing methods of cultivation may be improved and that the corn plant is subject to climatic conditions, to diseases and to insect pests should be matters of common knowledge but the detailed discussion of these points should never be made the chief characteristics of a study of corn in a science course required of all high school pupils.

If we turn to the materials treated in domestic economy we find a similar situation. Everybody should know certain truths concerning foods and nutrition but we may safely leave to the class in domestic science the study of the art of cooking foods and much of the science involved in their preparation. Everybody is interested in food values and in the comparative costs of foods but we are willing that the detailed study of food values and balanced rations shall be taught in the domestic science class as well as the art of setting the table, arranging the knives, forks and spoons and a multitude of other details.

It seems perfectly clear to me that there is a great body of science material dealing with the environment of all high school students which has practically uniform significance in their lives. This material, therefore, is of equal value to all high

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school students; it is also nearly equally accessible to them. The basic course in high school science must deal with this body of science materials found in the environment of the pupils and it must develop out of a study of this material the principles of science which have universal significance.

Advantages of a Generally Adopted Basic Course.

From an administrative point of view it is clearly advisable that all high schools adopt a uniform science curriculum so far as it is possible to do so without sacrificing the interests and welfare of the pupils. Such a plan, if generally adopted, would enable the pupils to do two years of science study in the two-year or the three-year high school and then complete the course in a four-year high school without loss. It would lessen expense and confusion in the large four-year high school by eliminating the need of differentiated science courses in the first two years. If such a course were required of all pupils in the first two years of the high school it would eliminate confusion and loss of time sometimes occasioned by pupils changing from one prescribed course to another within the same high school. Finally, I believe that colleges and universities could more easily adapt their entrance requirements and the first courses they offer to such a uniform preparation than they can to the extremely varied preparation which applicants for admission now offer.

Elective Science Courses.

The two-year required basic course in science must not be the only science course offered. In every rural high school courses in agriculture should be offered; in practically all high schools courses in domestic economy should be offered. Inasmuch, however, as the basic course will deal largely with materials which are closely related to the materials utilized in agriculture and domestic economy courses, these special courses may be shortened materially. Most high schools will also offer courses in special science, such as physical geography, physiology, general biology, physics and chemistry. The extent to which these elective courses can be offered will be determined by the facilities of the school.

Even the special science courses in the high school of tomorrow must undergo readjustment. Probably they will still have the special science organization, i. e., the units of instruction will be the artificial, man-made units and the principles will be developed through the study of the most pronounced types;

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still it is inevitable, I believe, that they will treat less of the theoretical aspects of science and more of the practical aspects. After having studied the practical aspects of science for two years in the general science course, pupils will *demand* that their later science courses have a much stronger bearing upon the practical, upon the here and now, than has been the case with any of our special science courses in the past. Many years of experience have taught me that pupils who have been trained in the study of applied science are rarely if ever satisfied unless the relation of the scientific principle to human welfare is made prominent.

Science in the Coming Junior High School.

Slowly but surely the 6-3-3 plan of organization of the public school is gaining ground. Eventually the junior high school will become an important reality. When that time comes we may hope to see science taught with success in the seventh and eighth grades. Properly trained teachers and properly equipped laboratories will be available. The seventh year may then well be devoted to nature study during the fall and spring months and to physiology and hygiene during the winter months. The first year's work of the proposed two-year course in general science can be done in the eighth year and the second year's work can be done in the ninth year. This will leave three years to be devoted to courses in agriculture, domestic economy or special science courses as they may be elected.

To High School Science Teachers.

Is it not worth while for high school science teachers, principals and superintendents to use every influence towards introducing some uniformity into our high school science curriculum? Is it not time that science teachers and high school principals should awaken to a realization of the chaotic condition into which high school science has been plunged? Are science teachers and principals willing that high school pupils shall be deprived of all science training during the first two years of the course except such as they may secure from the ordinary courses in agriculture and domestic economy?

I believe that this is an opportune time for all teachers who are interested in high school science and who appreciate its value as a vital factor in education to get together, forget their allegiance to some pet field of science, and unite upon some common plan for the placing of high school science in its rightful place as an important factor in universal education.

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GLACIAL MORAINES IN THE VICINITY OF ESTES PARK, COLORADO.

By LYMAN C. WOOSTER,
State Normal School, Emporia, Kansas.

While spending his August vacation near Estes Park village, the writer unexpectedly penetrated a region of enormous glacial activity of prehistoric times. Having given years to the study of the moraines of Kansas, Wisconsin, Michigan, Illinois, Indiana and Ohio belonging to the great continental glacier that once covered the northern United States from Dakota to Cape Cod, the writer became at once interested in these moraines of the alpine glaciers of the Rocky Mountains that formerly filled the upper valleys of the Thompson River and its tributaries.

The introduction to the moraines came when a party of relatives and friends laid a picnic luncheon in the Thompson River at the gateway to Moraine Park. Giant boulders filled the river, so we were safe from a wetting. The river here falls in cascades one hundred feet through and over the terminal moraine of a glacier that formerly filled Moraine Park. This glacier undoubtedly received tributary ice rivers down Forest, Spruce and Fern Canyons and was in its time a glacier of no mean dimensions. It pushed but two or three miles beyond the mouths of the canyons, for it encountered a great glacier from the southwest and the two stopped in the narrow gap between Eagle Cliff and Giant-track Mountains and here left their front moraines. Later, when the Moraine Park glacier melted back to and up the canyons, the front and lateral moraines impounded the water from the melting ice and thus produced a lake two or three miles in length and nearly one mile in width.

Gradually this lake became filled with silt from the mountains and the moraines, slowly the outlet of the lake lowered its channel through the front moraine till in the course of time the green of dry land replaced the blue of the water and Moraine Park was formed.

Students of Rocky Mountain history will be interested in a boulder which lies at the gateway to the park which shows that the present mountains were formed where ancient mountains had yielded to the pounding of the waves of an old-time ocean. This boulder consists of rounded pebbles of granite, mica schist and beach sand all fused into a compact rock when the present mountains were crushed and folded and made into a mighty range during the Tertiary period.

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On the north side of Moraine Park lies a moderately developed lateral moraine, but on the south side is the remarkable ridge of boulders from which the park takes its name. At its middle part this moraine rises five hundred feet above the park floor on the north and four hundred feet above the valley of Mill Creek on the south. From this middle point the moraine slopes endwise to the eastward till it dies down a short distance beyond the terminal moraine on the Thompson River. From its remarkable development and its straight course this moraine must have been formed between two glaciers and is therefore an interglacial moraine comparable with the interlobate moraines of the continental glacier of Wisconsin and eastward. It would be strange if there were not a ridge of gneiss in the axis of this moraine but no rock in place was observed.

Still further south, between Mill Creek and Glacier Creek, is another moraine of similar character but of more massive proportions. Its crest is a thousand feet higher than the crest of its companion interglacial moraine to the north and it rises six hundred fifty feet above the valley of Glacier Creek on the south. This interglacial moraine heads near Flat-top Mountain and Halletts Peak and extends in a northeasterly direction nearly to the Y. M. C. A. conference grounds. It must have been formed from glaciers that flowed down Mill Creek valley on the north and a powerful group of ice rivers on the south which flowed out of Glacier Gorge, Loch Vale and the Tyndall Glacier Valley. The southern slope of the moraine is very abrupt and can be climbed by horses only by following a zigzag trail. The northern slope is more moderate and is heavily forested with pine, especially in the vicinity of Bierstadt Lake and Bear Lake.

Other moraines undoubtedly border the valleys in this heavily glaciated region north of the Longs Peak group of mountains but more time than the writer had at his disposal would be necessary to enable one to make a detailed description of them.

Four miles up Fall River from Estes Park village, a short distance beyond the Fish Hatchery, is the best developed terminal moraine seen in the vicinity of Estes Park. Fall River tumbles in a series of cascades over the successive ridges of this moraine down a total distance of five hundred feet. In general appearance, these morainic ridges greatly resemble similar ridges in the bluffs south of Whitewater, Wisconsin, belonging to the moraine of the Wisconsin glacier.

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Beyond the terminal moraine of Fall River valley the melting glacier left a lake four miles long and half a mile wide. This in time became filled with sediment and is now Horseshoe Park. On either side of the park are weak lateral moraines.

Perhaps the most unique glacial phenomena are shown in the valley of Roaring River, a small stream which joins Fall River from the north near the head of Horseshoe Park. The glacier which plowed its way down Fall River valley carried a heavy body of ice which cleaned out the valley from mountain to mountain on either side and cut very deep, so deep that Roaring River was left with its mouth two hundred feet above the level of the main stream and is compelled to reach it down a series of waterfalls. Above these falls the river descends two thousand feet in five miles, so, rapids and waterfalls characterize the stream nearly to its source. The glacier that plowed out the valley of this river must have been comparatively weak, for even with its high gradient it did not cut as deeply as the one which filled Fall River valley. The weakness of the glacier is still further shown by the number of recessional moraines between the mouth and the source of the stream. The ice river flowed to its junction with the main glacier for unknown thousands of years in what the geologist terms a hanging valley, then as warmer years succeeded colder years it repeatedly melted back longer distances and advanced shorter distances till it retreated to its mountain source in the ridge connecting Mount Fairchild and Hagues Peak and ceased to exist as an ice river. The final retreat of this glacier may be seen today in a cirque, at the base of the ridge, scoured smooth by the ice.

Just in front of the last recessional moraine of this glacier, at a level five hundred feet below its summit, is Lawn Lake, and back of the moraine in hollows in the rock are two or three small bodies of water termed lakes. Snowdrifts lie here and there but with no indication of flowage except in one drift high up on the sides of Mount Fairchild. This has the ribbed appearance later seen on the surface of Halletts Glacier.

Part of the ice that pushed beyond Lawn Lake may have crossed over into Black Canyon through a low place in the divide now occupied in part by small lakes. This will account for the weakness of Roaring River glacier in the lower part of its course. At about the place of division of Roaring River glacier the right or western arm of this ice river encountered

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a low mountain, divided, passing around the mountain and united below it. This mountain was thus a nunatak in a field of ice. Most of the water flows at present on the eastern side, but a small lake was seen in the western valley.

Halletts Glacier was the last objective in this August vacation. Our party, consisting of a nephew, two daughters, a minister and the writer climbed the ridge connecting Hagues Peak with Mummy Mountain from the cirque of Roaring River glacier up a slope covered so thickly with disintegration boulders that the solid rock of the ridge was nowhere visible; and thence we descended four or five hundred feet to Halletts Glacier. The ridge has an elevation of thirteen thousand four hundred feet above sea level and gave a fine view of the glacier lying in its cirque below with its terminal moraine immediately below it. On descending to the moraine we found that it consisted of great, angular boulders forming a terminal moraine in front of the ice, rising, like so many others in the Estes Park region, five hundred feet above the creek erosion valley below.

Apparently Halletts Glacier has never left the cirque which it has excavated on the east side of the ridge extending north from Hagues Peak but has continuously shoved out disintegration boulders which it has plucked from the ridge behind it and has thus backed into the ridge. Sometime it will back through where gaps are already visible and the glacier will cease to exist.

On crossing the ridge connecting Mummy Mountain with Hagues Peak, the first view of Halletts Glacier was very fine, almost awe-inspiring. The glacier was glistening white from newly fallen snow and seen from a height of five hundred feet in its setting of black rock on all sides, one felt like sitting down and studying it as he would an oil painting.

Halletts Glacier is properly a névé, and, while it is still alive and has a crevasse where the névé drops from a higher to a lower level, the glacier has done little work beyond excavating its cirque and pushing out its great terminal moraine of blocks of gneiss.

The winter preceding our visit had been very stormy and the cirque was unusually full of snow at the time of our visit in August, so we had no opportunity to visit the crevasse and get a view of the interior of the névé. The concave surface of the névé is evenly ribbed from back to front. No attempt was made to find the cause of the ribbing but no other bodies

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of snow had the ribbed surface except one high up on Mount Fairchild and it was therefore surmised that the ridges were produced by the motion of the glacier.

The mountains of the Estes Park region consist chiefly of gneiss and mica schist. Even the so-called Pillars of Hercules in Thompson Canyon are but the edges of layers of fine textured mica schist. The boulders of all the moraines have not been moved more than fifteen miles, most of them not more than five or six. They are therefore still angular like the disintegration boulders of Hagues Peak and have not been smoothed by sliding. It may be of interest to the mineralogist to learn that many of the boulders on the slopes of the ridge connecting Hagues Peak and Mummy Mountain contain twin crystals of feldspar.

Several vacations would be required for a complete study of all these morainic ridges in the vicinity of Estes Park, but such studies would take one into a region replete with gorges, snow fields and rugged mountain peaks and would fill the hearts of the fisherman, mountain climber, teacher of physical geography, geologist and artist with the deepest pleasure.

CAROLINA TIN DEPOSITS.

The United States Geological Survey, Department of the Interior, has recently issued a report on the tin resources of the Kings Mountain District, North Carolina and South Carolina. The presence of cassiterite, oxide of tin, at many places in the district has led to much prospecting and to attempts at mining. In at least one place—the Ross mine, near Gaffney—placer mining was temporarily profitable. Practically all the work on the lodes, which are pegmatite dikes carrying cassiterite, has been done at a loss but the results of this work have not been sufficiently conclusive to prove or disprove the value of some of the deposits. The report can be had free on application to the Director, U. S. Geological Survey, Washington, D. C., asking for Bulletin 660-D.

THE WAY TO PEACE.

"Any body of free men that compounds with the present German Government is compounding for its own destruction. . . . Any man in America or anywhere else that supposes that the free industry and enterprise of the world can continue if the Pan-German plan is achieved and German power fastened upon the world is as fatuous as the dreamers in Russia. What I am opposed to is not the feeling of the pacifists but their stupidity. . . .

"If we are true friends of freedom of our own or anybody else's we will see that the power of this country and the productivity of this country are raised to their absolute maximum, and that absolutely nobody is allowed to stand in the way of it.

"Our duty is to stand together night and day until the work is finished."
—From President Wilson's Address to the American Federation of Labor.

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.
Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember, however, that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Correction (*Problem* 527).

The following communication from *Prof. B. F. Yanney, Wooster, Ohio,* explains itself. The Editor confesses to the mistake, practically the same as pointed out by him in the issue of June, 1917, under the discussion of Problem 511.

> "Permit me also to call attention to what I believe to be an erroneous statement in your solution of Problem 527. You develop your formula for n on the theory of remainders after monthly payments of $50 have been made. Now the presumption is, and your result clearly shows, that there is not an exact number of these monthly payments of $50. Evidently, after the 101st payment there is still a residual, not zero. So that your explanation leading up to the formula is hardly the correct one. The formula, however, is all right. One way of explaining is to let n equal the time during which the compound amount of the unpaid balance of $4,000 at the nominal rate of 6% (also the effective rate here) becomes equal to the final value of the $50 monthly payment (annuity) at the effective rate in this case of $(1.06)^{1/12}-1$, and so on."

Fallacy.

541. *Proposed by the Editor.* (See December, 1917, number. Problem 529 is restated below.)

Find the error in the published solution of 529. A correct solution would also be acceptable.

I. *Solution by B. F. Yanney, College of Wooster, Wooster, Ohio.*

The error in question is in the statement,

"$\angle$P equals 1/2 half circle HER less arc HK," which is tacitly assuming that diameter HP of circle S is tangent to circle T.

The theorem is essentially that of Exercise 615 in the 1882 edition of Todhunter's *Elements of Euclid,* and its proof depends upon Exercise 614 of the same book, which latter says:

"The opposite sides of a quadrilateral inscribed in a circle when produced meet at P and Q. Show that the square on PQ is equal to the sum of the squares on the tangents from P and Q to the circle."

We may then prove 529 as follows:

Let O be the center and r the radius of the given circle S. Let C be

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the center and R the radius of the circle described on PQ as diameter. Let t_1 and t_2 be the tangents from P and Q, respectively, to circle S.

Now, as is well known, $\overline{OP}^2+\overline{OQ}^2 = 2\overline{OC}^2+2R^2$.

But $\overline{OP}^2 = r^2+t^2_1$, $\overline{OQ}^2 = r^2+t^2_2$, and $4R^2 = \overline{PQ}^2 = t^2_1+t^2_2$.

Therefore, by substitution and reduction, we obtain

$$\overline{OC}^2 = r^2+R^2,$$

which easily leads to the desired result.

Exercise 614 of Todhunter's *Euclid* can be proved by aid of Exercise 309 of the same work, and this in turn by means of well-known principles of elementary geometry.

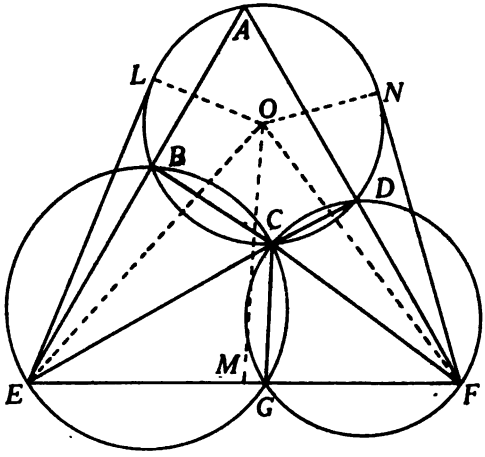
The error in 529 was also pointed out by R. M. MATHEWS.—*Ed.*

Geometry.

529. *Proposed by R. T. McGregor, Nord, Cal.*

The circle whose diameter is the third diagonal of a quadrilateral inscribed in another circle cuts the latter orthogonally.

Solution by E. L. Brown, Denver, Col.



Let ABCD be the cyclic quadrilateral, EF its third diagonal.

Draw FN, EL, tangents to circle O. Let M be mid-point of EF, hence center of circle on EF as a diameter.

We will first prove $\overline{EF}^2 = \overline{FN}^2+\overline{EL}^2$.

About CDF describe a circle CDFG, cutting EF in G. Join CG.

The angles BAD, BCD are supplementary; also the angles DFG, DCG are supplementary. Therefore the angles BAD, BCD, DFG, DCG together make four right angles. The angles BCD, BCG, DCG also make four right angles. Therefore, BCG = BAD+DFG, and BCG+BEG = EAF+AFE+AEF. Hence angles BCG and BEG are supplementary, and BCGE is a cyclic quadrilateral. Therefore $FE \cdot EG = DE \cdot EC = \overline{EL}^2$, and $EF \cdot FG = BF \cdot FC = \overline{FN}^2$. But $FE \cdot EG + EF \cdot FG = \overline{EF}^2$.

Therefore $\overline{EF}^2 = \overline{FN}^2+\overline{EL}^2$.

Now let OL = ON = r, and EM = MF = R. Join O to L, N, F, M, E.

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$$\overline{EL}^2 = \overline{EO}^2 - r^2, \text{ and } \overline{FN}^2 = \overline{OF}^2 - r^2.$$
$$\therefore \overline{EL}^2 + \overline{FN}^2 = \overline{EO}^2 + \overline{OF}^2 - 2r^2.$$
$$\overline{EO}^2 + \overline{OF}^2 = 2\overline{OM}^2 + 2R^2.$$
$$\therefore \overline{EL}^2 + \overline{FN}^2 = 2\overline{OM}^2 + 2R^2 - 2r^2.$$
$$\text{But } \overline{EL}^2 + \overline{FN}^2 = \overline{EF}^2 = 4R^2.$$
$$\therefore 4R^2 = 2\overline{OM}^2 + 2R^2 - 2r^2.$$
$$\therefore \overline{OM}^2 = R^2 + r^2.$$

Hence circles whose centers are O and M are orthogonal.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let A, B, C, D be four points on the circumference of a circle, and let connectors AD and BC intersect at G, the connectors CD and AB intersect at F, the connectors BD and AC at E.

Then EFG is a self conjugate triangle (Lachlan's *Modern Pure Geometry*, §270).

Hence, G is the pole of EF and F is the pole of GE, and G and F are conjugate points with respect to the given circle.

Therefore, the circle whose diameter is FG cuts the given circle orthogonally. (Lachlan, §260).

NOTE: Problem 529 is one case of the following:

Circles whose diameters are the sides of the central tetrastigen inscribed within a circle cut the given circle orthogonally.

One incorrect solution received.—Ed.

Algebra.

542. *Selected from College Entrance Examinations (September, 1917), Advanced Algebra.*

How many numbers between 100 and 1,000 may be formed from 0, 1, 2, 3, 4, 5, 6, no digit being repeated in any number? How many of these are even?

I. *Solution by L. E. Lunn, Heron Lake, Minn.*

As the problem is stated, three place numbers are required. For the first place, i. e., the hundreds digit, we have only six choices, since we cannot use the 0 in this place. Then for the tens digit there remain six numbers to choose from, and for the units digit five choices.

The total number of numbers is then 6x6x5 or 180.

Since 0 cannot be used in hundreds place, there are three even and three odd digits for use in this place. Then just half, or 90 of the numbers will have an even number in hundreds place.

Of the 90 numbers having an even number in hundreds place there will remain three even numbers for units place, and 1, 3, and 5 odd numbers in units place. This will give just half of these 90 numbers even and half odd. There are then 45 even numbers in this group.

Of the 90 numbers having an odd number in hundreds place, there remain 0, 2, 4, and 6, even numbers, and but two odd digits for use in units place. Then two-thirds of this group will be even. This gives 60 even numbers out of this group.

There will then be a total of 105 even numbers in the 180 three place numbers.

Writing the numbers verifies this result.

II. *Solution by R. M. Mathews, Riverside, Cal., and R. T. McGregor, McArthur, Cal.*

Using the notation ${}_nP_m$ for permutations of n things m at a time, we have,

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Numbers without zero: ${}_4P_3 = 120$
Numbers with zero tens: ${}_4P_2 = 30$
Numbers with zero units: ${}_4P_2 = 30$

Total ---------- 180 numbers.

Since half the digits are even and half odd, just half the first group will end in an even digit and so be even numbers. All of the last group will be even. Thus 105 of the 180 will be even numbers.

Also solved by C. E. GITHENS.—*Ed.*

Geometry.

543. *Selected from College Entrance Examinations (September, 1917), Elementary Geometry.*

If ABC is a right triangle with the right angle at B, and if D is a point on AC such that AB is the mean proportional between AC and AD, prove that ADB is a right angle.

I. *Solution by Geo. H. Olson, Nevis Minn. (Solutions differing from this only in minor details received from Edward S. Mooney, South Dayton, N. Y., W. W. Gorsline, Chicago, Isidore Ginsberg, New York City, and R. M. Mathews, Riverside, Cal.*

Join D with A. The triangles ABC and ADB are similar, having an acute angle of the one equal to an acute angle of the other, and the including sides proportional. Similar triangles have their corresponding angles equal, hence angle ADB is equal to angle ABC. Angle ABC is by hypothesis a right angle, hence angle ADB is a right angle.

II. *Solution by Grover C. Koffman, Hopkinsville, Ky.*

If BD is not perpendicular to AC, draw BM perpendicular to AC.

Then

$$\overline{AB}^2 = AC \cdot AM.$$

But

$$\overline{AB}^2 = AC \cdot AD.$$

Therefore, AD coincides with AM and BD is perpendicular to AC.

III. *Solution by L. E. Lunn.*

Given: Right triangle ABC, and point D on AC, and $(AB)^2 = AC \times AD$.

To prove: $\angle ADB = 90°$.

Proof:

1. $\overline{AB}^2 = AC \times AD$
2. Then $\dfrac{AB}{AD} = \dfrac{AC}{AB}$ (dividing Equation 1 by $AB \times AD$)
3. Then DB and BC are either parallel or anti-parallel. (Two lines which cut off proportional sects from the sides of an angle are either parallel or anti-parallel, and the triangles formed are co-sensal or non-co-sensal respectively.)
4. It then follows that DB and CB are anti-parallel and that the triangles are similar non-co-sensal triangles.
5. Since $\angle B$ is given a right angle, then by 4 it follows that $\angle D$ is also a right angle.

Solutions were also received from NELSON L. RORAY, R. T. MCGREGOR, M. T. NOLAN, *and* ERNEST H. H. SANGER. *A second solution was received from* GEO. H. OLSON.—*Ed.*

Trigonometry.

544. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

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The angles of a plane triangle form a geometrical progression of which the common ratio is 1/2. Show that the ratio of the greatest side to the perimeter is $2\sin\pi/14$.

I. *Solution by R. M. Mathews, Riverside, Cal.*

Let $4a$, $2a$, a be the angles of the triangle. Then $a = \pi/7$.

By the law of sines:

$$\frac{a}{\sin 4\pi/7} = \frac{b}{\sin 2\pi/7} = \frac{c}{\sin\pi/7},$$

whence by composition and alternation

$$\frac{a}{a+b+c} = \frac{\sin 4\pi/7}{\sin 4\pi/7 + \sin 2\pi/7 + \sin\pi/7}$$

Replace $\sin\pi/7$ by its equal $\sin 6\pi/7$ and use the formula for the sum of two sines and we have

$$= \frac{\sin 4\pi/7}{\sin 4\pi/7 + 2\sin 4\pi/7 \cos 2\pi/7} = \frac{1}{1+2\cos 2\pi/7}$$

Substitute $\sin 4\pi/7 / \sin 2\pi/7$ for $2\cos 2\pi/7$ and simplify:

$$= \frac{\sin 2\pi/7}{\sin 2\pi/7 + \sin 4\pi/7} = \frac{2\sin\pi/7 \cos\pi/7}{2\sin 3\pi/7 \cos\pi/7}$$

$$= \frac{\sin\pi/7}{\sin 3\pi/7} = \frac{2\sin\pi/14 \cos\pi/14}{\cos\pi/14} = 2\sin\pi/14.$$

$(\sin 3\pi/7 = \cos(\pi/2 - 3\pi/7) = \cos\pi/14)$.

II. *Solution by E. L. Brown, Denver, Col.*

In any triangle

$$\frac{a+b}{c} = \frac{\sin A + \sin B}{\sin C} = \frac{\sin\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)}{\sin\frac{1}{2}C\cos\frac{1}{2}C} = \frac{\cos\frac{1}{2}(A-B)}{\cos\frac{1}{2}(A+B)} \qquad (1)$$

Adding unity to each member of (1),

$$\frac{a+b+c}{c} = \frac{\cos\frac{1}{2}(A+B) + \cos\frac{1}{2}(A-B)}{\cos\frac{1}{2}(A+B)} = \frac{2\cos\frac{1}{2}A\cos\frac{1}{2}B}{\sin\frac{1}{2}C} \qquad (2)$$

Let $B = \frac{1}{2}C$, $A = \frac{1}{2}C$.

Then $A+B+C = 7C/4 = \pi$.

$\therefore C = 4\pi/7, B = 2\pi/7, A = \pi/7.$ (3)

From (2) and (3),

$$\frac{a+b+c}{c} = \frac{2\cos\pi/14 \cos\pi/7}{\sin 2\pi/7} = \frac{\cos\pi/14}{\sin\pi/7} = \frac{1}{2\sin\pi/14}.$$

III. *Solution by Murray J. Leventhal, New York City.*

Let $4x$, $2x$, and x be the angles of the triangle, so that the corresponding opposite sides may be represented by $d\sin 4x$, $d\sin 2x$, and $d\sin x$, where d is a constant. Then,

$$\text{the greatest side : perimeter} = \sin 4x : (\sin 4x + \sin 2x + \sin x)$$
$$= \sin 4x : 4\cos 2x \cos x \cos x/2$$
$$= 2\sin x/2 = 2\sin\pi/14,$$

since from the hypothesis, $7x = \pi$ and $x = \pi/7$.

Solutions were also received from C. E. Flanagan, Isidore Ginsberg, W. W. Gorsline, L. E. A. Ling, Nelson L. Roray, *and* Samuel Wolff. —*Ed.*

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545. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Express $\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1$ as the product of four cosines.

I. *Solution by E. L. Brown, Denver, Col.*

$\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1 =$

$(\sin\alpha-\sin\beta\sin\gamma)^2-\sin^2\beta\sin^2\gamma+\sin^2\beta+\sin^2\gamma-1 =$

$(\sin\alpha-\sin\beta\sin\gamma)^2-(1-\sin^2\beta)(1-\sin^2\gamma) =$

$(\sin\alpha-\sin\beta\sin\gamma)^2-(\cos\beta\cos\gamma)^2 =$

$(\sin\alpha-\sin\beta\sin\gamma-\cos\beta\cos\gamma)(\sin\alpha-\sin\beta\sin\gamma+\cos\beta\cos\gamma) =$

$[\cos(90-\alpha)-\cos(\beta-\gamma)][\cos(90-\alpha)+\cos(\beta+\gamma)] =$

$$-4\sin\left(\frac{90-\alpha+\beta-\gamma}{2}\right)\sin\left(\frac{90-\alpha-\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha+\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha-\beta-\gamma}{2}\right) =$$

$$-4\cos\left(\frac{90+\alpha-\beta+\gamma}{2}\right)\cos\left(\frac{90+\alpha+\beta-\gamma}{2}\right)\cos\left(\frac{90-\alpha+\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha-\beta-\gamma}{2}\right).$$

II. *Solution by the Proposer.*

$\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1 =$

$\sin^2\alpha+\sin^2\beta-\cos^2\gamma-2\sin\alpha\sin\beta\sin\gamma$

$= \sin^2\alpha-\cos(\beta+\gamma)\cos(\beta-\gamma)-2\sin\alpha\sin\beta\sin\gamma$

$= \sin^2\alpha-\cos(\beta+\gamma)\cos(\beta-\gamma)-\sin\alpha[\cos(\beta+\gamma)-\cos(\beta-\gamma)]$

$= [\sin\alpha+\cos(\beta+\gamma)][\sin\alpha-\cos(\beta-\gamma)]$

$= [\cos(\pi/2-\alpha)+\cos(\beta+\gamma)][\cos(\pi/2-\alpha)-\cos(\beta-\gamma)]$

$$= -4\left[\cos\left(\frac{\alpha+\beta+\gamma}{2}-\frac{\pi}{4}\right)\cos\left(\frac{\pi}{4}+\frac{\beta+\gamma-\alpha}{2}\right)\cos\left(\frac{\pi}{4}+\frac{\alpha+\beta-\gamma}{2}\right)\cos\left(\frac{\pi}{4}+\frac{\alpha+\gamma-\beta}{2}\right)\right].$$

One incorrect solution was received.—Ed.

PROBLEMS FOR SOLUTION.

Algebra.

556. *Proposed by L. E. Lunn, Heron Lake, Minn.*

A fast half back finds himself free with the ball 40 yds. from the side line. Thirty yards ahead of him is his only opponent, a slower man, whom he knows he can outrun by four feet to three feet. Can he escape? If not how should he lay his course to gain the most ground before being tackled?

Geometry.

557. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

If ABC is a triangle inscribed in a circle, and from the middle point D of the arc BC a perpendicular DE is drawn to AB, then $AE = 1/2\,(AB+AC)$ and $BE = 1/2\,(AB-AC)$.

558. *Proposed by Murray J. Leventhal, New York City.*

From a given point without a triangle to draw a line bisecting the triangle.

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559. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle, having given a side, an angle adjacent to it, and the difference of the medians through its extremities.

560. *Proposed by I. N. Warner, Plattesville, Wis.*

Show that the following construction does, or does not, give a regular pentagon.

To a given side AB construct RP perpendicular to its mid-point, R, and equal to AB. Draw AP and extend it to S, making PS = AR. With A as center and AS as radius draw an arc cutting RP extended, at D. A, B, and D are three of the required vertices, and AB a given side, so that C and E are easily determined by using the compasses. Then is ABCDE a regular pentagon?

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Examination Papers.

The receipt of entrance examination papers is gratefully acknowledged from Amherst College, College Entrance Examination Board, Boston University, University of California, Columbia University, Cornell University, University of Illinois, Massachusetts Institute of Technology, McGill University, Mt. Holyoke College, University of Pennsylvania, Rensselaer Polytechnic Institute, Stevens Institute of Technology, University of Toronto, Trinity College, Wellesley College, and Williams College.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Send your first term examination now.** If a representative number of papers in physics, chemistry and other sciences can be obtained, the Editor will attempt a comparison of school with college entrance examinations.

[**Please note carefully.**—The Editor does not assume that they should be the same or even correspond.]

Science Tests.

In May, 1917, question number 269 was published for the express purpose of arousing interest in science testing. The following have expressed a desire to cooperate in working on the problem: A. B. Bucknam, Crosby H. S., Waterbury, Conn.; Miss Jessie Caplin, West H. S., Minneapolis, Minn.; H. Lawton Chase, Claremont, N. H.; Miss Annie Cloyd, Sewickley, Pa.; Lewis H. Fee, Everett H. S., Everett, Wash.; P. C. Hyde, Newark Academy, Newark, N. J.; Walter N. Lacy, Anglo-Chinese College, Foochow, China; L. E. Lunn, Heron Lake, Minn.; S. R. Powers, University H. S., Minneapolis, Minn.; Hanor A. Webb, Peabody Col. for Teachers, Nashville, Tenn.; T. R. Wilkins, University H. S., Chicago, Ill.

Will the above, or others who are interested in physics, please notify the Editor how soon they could use some testing material on heat? On light? On electricity? On sound? On mechanics? Can you get data also from other classes than your own?

Likewise in chemistry?

General Science.

Please send to the Editor of this department an outline of your course in general science. In what year or years is the subject taught? Would

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two years of general science two or three periods per week be better than one year five periods per week? Has your course in general science a unifying principle? If so, what is it?

Send your examination paper in general science.

Questions and Problems for Solution.

295. *Proposed by S. R. Powers, Minneapolis, Minn.*

"We find, as we continue to dilute an electrolyte, that the molecular conductivity increases up to a certain point beyond which it does not change. This might be expected for, at a certain dilution, *all* the molecules are dissociated and a further dilution causes no further dissociation." [Quoted from a recent high school test.]

Is this true? Is 100% dissociation attained?

296. *Proposed by G. Ross Robertson, Polytechnic H. S., Riverside, Cal.*

We are told that a wet object dries faster on a dry day than on a humid day because, at the former time, the air has a large reserve capacity for water-vapor. If this is so, why does an object wet with varnish dry faster on a dry day than on a humid day? It must be noted that on neither day does the air contain turpentine vapor—the volatile substance involved.

297. *Proposed by J. C. Packard, Brookline, Mass.*

Will a siphon work in a vacuum?

[Mr. Packard says that "a professor in ——— University stated a few years ago, in my hearing, that he had tried the experiment and that the siphon did work up to a height of (about) 20 inches owing to the cohesion of the water." Try it.]

SOLUTIONS AND ANSWERS.

275. *Proposed by Daniel Kreth, Wellman, Iowa.*

A stream of water, 4 feet deep, flows at the rate of 5 ft. per second. It is required to lower the water by means of a "drop" so that the bottom of the stream below the "drop" is 4 ft. lower than it is above the "drop." What must be the dimensions of the pit below the "drop" so that the water acts as a cushion to prevent the water striking the ground?

Answered by Arthur E. Morgan, Chief Engineer, Miami Conservancy District, Dayton, Ohio.

Belassis in "River and Canal Engineering," p. 113, gives a formula for the depth. [The answer in full has been sent to Mr. Kreth. Those interested may correspond directly with him. EDITOR.]

279. *Proposed by John C. Packard, Brookline, Mass.*

Can a real image be formed by the action of a plane mirror? [Suggestion—Consider the use of a plane mirror in connection with the reflectoscope.]

Answered by F. T. Jones.

A real image cannot be formed by a plane mirror but the mirror may be used to change the direction of rays of light, whether parallel rays, or converging, or diverging. In the reflectoscope the mirror changes the direction of all the rays that fall upon it without changing their properties. If converging to form a real image before plane reflection, they remain converging afterwards.

280. *Proposed by A. Haven Smith, Riverside Junior College, Riverside, Cal.*

A cylindrical shaft 4 inches in diameter, weighing 80 lbs., turns without friction about a horizontal axis. A fine cord is wrapped around it by which a 20-lb. weight hangs. How long will the weight take to descend 12 feet?

Solved by Wm. F. Rigge and J. P. Drake.

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Solution by Wm. F. Rigge.

I think the whole subject of moment of inertia as given in our textbooks is generally too repellantly abstruse for students. The formula I use is as simple, I think, as it can be made. Thus we have the moment of inertia $= K = Fb/a$, in which F is the force causing rotation, b its lever arm, Fb then the moment, and a the angular acceleration.

If m = pulling weight attached to the cord, its own acceleration in falling, g, is diminished by the acceleration a it must give to the shaft, so that $F = m(g-a)$. But $a = ra$, and $a = a/r$,
hence

$$K = \frac{Fb}{a} = \frac{m(g-a)r}{a} = \frac{m(g-a)r}{a/r} = \frac{mr^2(g-a)}{a}.$$

If a = the length of cord unwrapped more every second = acceleration of the falling weight, the theoretical moment of inertia $K = 1/2Mr^2$ is equal to the observational one of $mr^2(g-a)/a$. This gives $a = 10\ 2/3$ feet in the present case. Then from the formula $s = 1/2at^2$, t is found to be 1 1/2 seconds.

This is the method the writer uses to find moment of inertia. Instead of the cumbersome and expensive blackened and graduated heavy disk, with its tuning fork and microscopes, he replaces the pulley of his Atwood's machine by a wooden disk and finds the acceleration a either directly or through the formula $s = 1/2\ at^2$.

282. *Proposed by W. A. Hedrick, Washington, D. C.*

Why not adopt metric measurements as the *sole* standard of units?

Answer by L. E. Lunn, Heron Lake, Minn.

For general use there is probably no reason against the general adoption of the metric system other than conservatism, which sees an immediate loss in discarding present measuring instruments standardized in other systems, and in operatives familiarizing themselves with a new system.

On the other hand, counting out the general recognized simplicity of operation, there is another and greater advantage in having a single standard of value the world over. This one fact would do a great deal toward bringing all nations closer together and would make international commerce a less complicated matter. There is indeed no intrinsic reason why we English speaking peoples cannot buy coal by the metric ton, butter and sugar by the kilogram, diamonds and gold by the milligram, take our medicine by the cubic centimeter, etc., throughout our daily life. There is one problem in the agricultural region of this country that will probably never fit into the metric system and that is the problem of land measurement. Our land is largely surveyed on a well organized plan based on the square mile as a unit. This could not well be changed.

Summarizing, then, we find that there is no real objection to the metric system outside the one mentioned problem, and that need not interfere with any other application. It is my own personal belief that we will in the near future see a general adoption of the metric system.

Comment by a superintendent at The Warner & Swasey Company.

The obstacle lies in the men. They are willing to work in English units but are unwilling to change.

283. *Proposed by R. A. Burtnett, Champaign, Ill.*

A 40-watt lamp burns for one hour immersed in 10 liters of water which is at 10° C. at the time the lamp is turned on. If lamp is 16 per cent efficient as a light, find the second temperature at the end of the hour.

Solved by A. H. Smith and J. P. Drake.

Solution by J. P. Drake, Emporia, Kans.

The light efficiency = 16%.

∴ the heat efficiency = 84%.

H = .24 × watts × time in seconds.

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H = .24×(40×.84)3600 = 29030 calories.
Rise in temperature = 29030/10000 = 2.9° C.
∴ Final temperature = 12.9° C.

284. *Proposed by William T. Reed, Woodlawn, Pa.*

Do you think it advisable to have all laboratory notes done in the "Lab."?

Answer by A. H. Smith, Riverside, Cal.

We think it advisable to have all laboratory work done in the laboratory. We have tried both plans, that is, all work done in the laboratory and as much as possible in the laboratory and the remainder at home.

We like the former for two reasons: It tends to keep the pupil from dilly-dallying over his task, and the temptation to copy is greatly reduced. We have found it necessary in some instances to cut down the number of trials required in a given experiment. We believe, however, the advantages of requiring that all the work be done in the laboratory greatly outnumber the few disadvantages.

Answer by J. P. Drake.

I am convinced that the notes should all be made in the laboratory and handed to the instructor as soon as completed.

285. *Proposed by M. W. Arps, U. S. S. Ohio, c-o Postmaster, New York.*

"A" claims that if two balls of equal diameter, but of different material, one being lead and the other wood, be dropped in air from a height of one mile, that they would both reach the ground at the same time.

"B" claims that the lead ball would reach the ground first. Which is correct?

Answer by L. E. Lunn, Heron Lake, Minn.

This question ignores the fundamental statement of the laws of gravitation. The statement of the laws of gravitation includes no other force acting on the body under consideration than that of the earth's gravitation. In this problem the resistance of the air exerts a retarding influence on both. The greater mass of the lead ball, however, gives it a greater momentum which overcomes the resistance of the air to a greater extent than does the wood ball. If the density of the wood be decreased indefinitely it will be found that as the density of the wood approaches the density of the air that its velocity will decrease and will approach zero.

Using distances less than about one hundred feet the writer has found that it is almost impossible to detect any difference in the fall of two such objects. Above this distance the difference is quite plainly apparent.

This same fact can be very plainly demonstrated by using a long glass tube (two meters in length is sufficient) filled with water. The writer recently used this method in his physics class, using an aluminum ball and a lead ball. The heavier ball reaches the bottom in much less time than the lighter one.

It should also be noted that as the velocity increases the resistance increases in a cubic ratio. This then is the reason why the difference is apparent only after some considerable distance of fall.

Answer by Annie Cloyd, Sewickley, Pa.

Barring the effect of the air, the balls will reach the ground at the same time, since all bodies fall with equal velocities except for the resistance of the air. Hence A was right.

Answer by Tracy F. Tyler, Wood River, Neb.

Both balls should reach the ground at the same time. Both balls should fall at the same rate.

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RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

One of the Proofs that Matter Is Mostly Empty Space.

One of the most interesting results of the recent discoveries of physics is the proof that any particular piece of matter is composed mostly of empty space. The idea that matter is the solid, substantial stuff which our senses reveal must give way before the more discriminating insight furnished by the kinetic theory. In fact, experiments and other proofs that molecules and atoms are in ceaseless motion, and that they are separated by comparatively large distances, have been familiar for many years.

But the molecule and the atom were still regarded as very substantial things. Even when the electron was discovered it was spoken of as something knocked off from the atom like a tiny nick from the surface of a marble. It was many years before the cloud of mystery enveloping the atom was at all dispelled. Recently, there have been striking and convincing proofs that the atom itself has but little within its boundaries that can be called matter.

One of the lines of investigation that have led to the conclusion that matter is nearly all empty space grew out of the work of C. T. R. Wilson. It was in 1912 that he first published photographs of the passage of α and β-particles through gases.[1]

The apparatus, like so much of that with which important work is done, is relatively simple. There was a source of α and β-particles, usually radium, which shot them through a chamber of moist air so arranged that the air could be easily expanded. On the expansion of the saturated air the moisture would collect on the ions[2] produced by the radioactive particles, and these drops of water were photographed.

In this way it was found that the α-particles ionize the gas to such an extent that their trails are marked by continuous rows of droplets showing upon the photographs as long straight lines, with here and there a sharp bend. The β-particles, on the other hand, produce for the most part isolated pairs of droplets. One of the pair is associated with the electron and the other with the positive portion of the atom. If we examine into the reasons for these effects we are led to interesting conclusions.

The α-particles are, as is well known, atoms of helium, and being heavy (four times the atomic weight of hydrogen) possess considerable energy even though they travel at a speed much slower than that of the electron. The β-particles have a mass approximately one two-thousandth of that of the hydrogen atom. Consequently, even though they travel at high speeds, they have very much less energy than the α-particles, and are

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[1] C. T. R. Wilson, Proc. Roy. Soc., London, 87, 277, 1912. Four of the photographs are reproduced in *The Electron* by R. A. Millikan from which we quote freely in this article, and two are to be found in *A First Course in Physics* by Millikan and Gale.

[2] Saturated water vapor will condense readily on ions and dust particles. When the air is dust free, each ion will, under the proper conditions, become the nucleus upon which a water droplet condenses.

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therefore less active in producing ionization of the gas through which they pass.

The big, slow-moving α-particle lumbers along and has plenty of time to disturb vast numbers of gas molecules and has sufficient energy to produce a great deal of ionization before anything happens to seriously disturb its own progress. The small, rapidly moving electron, or β-particle, dashes through so rapidly that it must come almost face to face with one of the electronic constituents of an atom in order to dislodge it and thus produce ionization.

One of the photographs which have been mentioned shows a series of a dozen pairs of specks lying in a straight line. These are the droplets which reveal the ionization from a single β-particle. Since the size of the molecule is known and the number per cubic centimeter, the number through which the β-particle must pass in going a given distance can be computed. The extraordinary situation revealed by this photograph is that this particular particle shot through as many as 10,000 atoms before it came near enough to any electronic constituent of any one of these atoms to detach it from its system and form an ion. This shows conclusively that the electronic or other constituents of atoms can occupy but an exceedingly small fraction of the space enclosed within the atomic system. Practically the whole of this space must be empty to an electron going with this speed.

Other photographs show the tracks of negative electrons of much slower speed and the curved paths and closer drops show that slow β-particles ionize much more frequently and are themselves deflected in the process. This can be readily understood from the following illustration. If a new planet or other relatively small body were to shoot with stupendous speed through our solar system, the time which it spent within our system might be so small that the force between it and the earth, or other member of the solar system, would not have time either to deflect the stranger from its path or to pull the earth out of its orbit. If the speed of the strange body were less, however, the effect would be more disastrous both to the constituents of our solar system and to the path of the strange body, for the latter would then have a much better chance of pulling one of the planets out of our solar system and also a much better chance of being deflected from a straight path itself. The more slowly a negative electron moves, then, the more is it liable to deflection, and the more frequently does it ionize the molecules through which it passes.

Turning now to the α-particles one finds that Wilson's photographs show that they shoot in straight lines through from three to seven centimeters of air before they are brought to rest. This means that an atom has so loose a structure that another atom, if endowed with enough speed, can shoot right through it, in some cases detaching an electron and in others producing no effect which can be detected. That the α-particle goes right through the atoms which it encounters is shown by the fact that it ionizes several times more violently toward the end of its path than toward the beginning, and it therefore loses energy more rapidly when it is going slowly than when it is going rapidly. If it pushed the molecules aside, as a bullet does, the resistance to its motion would be the greatest when its speed was the highest.

Further, an α-particle is deflected more readily as it slows down. The photographs show sharp bends near the ends of the paths. This gives important evidence concerning the structure of the positive core of the atom. The α-particles, being about eight thousand times more massive than negative electrons, can produce the tremendous amount of ionization represented by the solid lines of droplets appearing in the photo-

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graphs. The encounter with electrons produces no deviation in the path of the particle. What, then, is responsible for the sudden deflections? They can only be produced by a very powerful center of force within the atom whose mass is at least comparable with the mass of the helium atom, i. e., the α-particle. The fact that the photographs show that the α-particle goes through as many as 500,000 atoms without approaching near enough to the central nucleus to suffer appreciable deflection more than two or three times, constitutes the most convincing evidence that the central nucleus, which holds the negative electrons within the atomic system as the sun holds in their courses the planets of the solar system, occupies an exceedingly minute volume. The evidence which has been reviewed in this article shows the atom to be mostly "hole." The nature of the very small amount of matter present in the nucleus and other points in connection with atomic structure will be considered in a later issue.

THE FIRST INTEREST INSTALLMENT.

On December 15 the first installment of interest on the two billion dollars of the first issue of Liberty Loan bonds became due. The amount approximated $35,000,000, being $1.75 interest on every one hundred dollars of bonds.

Holders of coupon bonds obtain their interest money from any bank or post office in the country by simply presenting their coupons. Holders of registered bonds are sent checks for their interest by the Treasury.

Hereafter every six months ten to fifteen million American citizens are to receive interest money on their Liberty Loan bonds from the United States Government. This is going to create a closer and more direct association of these citizens with their Government, and the effect of this association is going to be of great value to these citizens and of great value to the nation in making them more personally interested in their Government and more active and alert in the exercise of their duties and rights as citizens. Every Liberty Bond holder is going to be an active champion of wise and economic legislation and administration.

The Liberty Loan is not only a great financial transaction; it is a great national force, a great national bond between the bondholders and their country, a great influence for better government and better citizenship.

ADVOCATES WATER-POWER LEGISLATION.

Noting the efforts of past years toward the enactment of legislation relating to the development of the water power of the nation, the Secretary of Agriculture, in his annual report, says that "it becomes increasingly urgent that amendments to existing law be made and that a well-rounded policy be decided upon." The report continues:

"The present industrial situation, and particularly the scarcity and high cost of fuel and construction materials, have increased the cost of steam power and make it highly important that action be taken at the next session of Congress. Legislation which will make it possible to safeguard the public interests, and at the same time to protect private investors, should result in securing cheaper water power and in conserving the coal and fuel-oil supply. Since three departments of the Government are vitally concerned in water-power legislation and its possible terms and would be vitally affected by the administrative handling of matters under such legislation, it would seem desirable to consider whether it is feasible to devise an executive body on which the three departments will be represented and which will be able to utilize to the best advantage all their existing agencies."

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MINUTES OF THE EARTH SCIENCE SECTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Meeting of Section called to order by the chairman, W. R. McConnell, State Normal School, Platteville, Wis.

Announcements: Nominating Committee: Dr. Geo. D. Hubbard, Oberlin, Ohio; Miss Josephine Leach, Toledo University, Toledo, Ohio. Reception at Library at 4:30 p. m. Dinner, Oxley Hall, 6 p. m. Lecture at University Chapel at 8:15 p. m.; topic, "Mt. Katmai—The Mountain of 10,000 Smokes," Dr. Robert Griggs, Ohio State University.

Program: "The Home State as a Geographic Unit," D. C. Ridgeley, State Normal University, Normal, Ill.

A paper, "The Materials for the Geography of South America," Isaiah Bowman, Director of American Geographic Society, N. Y., was read by title only, Mr. Bowman not being present.

B. H. Schockel, State Normal School, Terre Haute, Ind., read an interesting paper on "The Geographic Influences in the French and Indian War."

The third speaker was Miss Josephine Leach of Toledo University, Toledo, Ohio, who spoke on "The Aims of Geography in the Elementary School." Miss Leach says geography is no longer a textbook only; the world of today must be brought into the classroom. Let the textbook be a book of reference. Use *topics*, as: South America. What are the natural controls? What helps? What hinders? What are the life responses to these natural controls? Compare South America with other continents. Groups of suggestive questions may be given, one or more to be chosen. Have some pivotal questions as, "Why is Africa the 'dark continent?'" Try to set up geographic concepts that may be used to measure and compare with other geographic matter as it comes to the attention of the student.

"The Aim and Content of Junior High School Geography," was discussed by W. M. Gregory, Normal Training School, Cleveland, Ohio. Mr. Gregory gave a suggestive course for the Junior High Schools; the work that is being tried out in Cleveland is the study of Cleveland—the geographic factors of its growth and development, its industries, people, trade, its needs and how they are supplied, its commercial products, the disposition of the same, etc.

After an animated discussion of all papers, the Section adjourned to meet again Saturday morning.

Saturday, December 1, 10 a. m.

Meeting called to order by President McConnell. Announcements, reports, etc.:

Excursions for afternoon: By automobile to filtration and garbage disposal plants. By interurban to glens worn in the shales of the upper Devonian; excursion conducted by Dr. John Bownocker, State Geologist.

Report of Nominating Committee, Dr. Hubbard, Chairman: Chairman for 1918, Mabel Stark, State Normal, Normal, Ill.; Vice-Chairman, C. H. Robinson, Montclair, N. J.; Secretary, Martha Linquist, Belvidere, Ill.; Chairman of Reception Committee, Eugene Van Cleef, Duluth, Minn.

Program:

"Reasons for Giving Geography a Greater Place in the High Schools," paper by Dr. Geo. D. Hubbard, Oberlin, O.

"Commercial Geography for the High Schools, Scope of a Unit Course," J. Paul Goode, Chicago University, Chicago, Ill.

A letter and partial report from J. H. Smith, Austin High School, Chicago, Ill., was read. Mr. Smith was chairman of a committee ap-

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pointed in 1916 to outline a course of Earth Science work for the reorganized high schools. The committee had not yet worked out a course of study that would be suited to the high schools as they are now conducted—Junior and Senior High Schools. One fact agreed upon was that more time should be spent on the *social* aspects and less on the physical. The attention of the whole section was given to the partial report of the committee, all those present taking part in the discussion. The matter is considered of such importance now in this reorganization time in the high schools that a motion was made to continue the committee. Mr. Smith has sent word that it would not be possible for him to be chairman. The motion was therefore amended to read: "Resolved, That a committee be appointed to go on with the work so well begun, and to bring in next year a course of study in Earth Science that will be suited to the Junior and Senior High School courses. Carried, Committee will be announced later.

STELLA S. WILSON,
Secretary pro tem.

MINUTES OF THE MATHEMATICS SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

November 30, 1917, 1:30 p. m.

The meeting convened with Mr. W. W. Hart of the University of Wisconsin in the chair, the general topic of discussion being mathematical aims and requirements.

Professor Harris Hancock, University of Cincinnati, read a paper on "What Course of Study Should be Taken by a Boy or Girl in High School"

Mr. Hart opened the discussion with the remark that there are educational aristocrats and educational democrats and that the judgment of the many is, in many things, of equal value to the judgment of the few.

Mr. Weaver of Ohio State University thought most of us miss the point of what to aim at in the educational scheme. Is it general education or special that is wanted? It is not so much subject matter as aims.

Mr. Comstock of Bradley Polytechnic Institute warned that the last word had not yet been said, that answers and questionnaires were not to be taken as final. If a man says mathematics gave him power of analysis then find out how much mathematics he had and what he did in the subject. A lawyer pinned down to answer whether geometry had helped, "Wasn't sure." Perhaps power came from other subjects. We must prove our point.

Further discussion was postponed until after Mr. Foberg's report from the Committee on Mathematical Requirements.

Report: The committee's work has been largely tentative as to: The value of mathematics for high school students; adaptation necessary to assure results but actual in the study of: Valid aims in teaching mathematics; bases of objection to mathematics; formal discipline, transfer of training, coefficient of correlation.

Mr. Foberg put much emphasis on the need of proving our point, not merely saying that mathematics is good for a student but showing why.

Investigation in the question of "transfer" has shown that much of the objection has been loudly voiced without foundation in proof. Miss Blair finds many instances of "transfer" and means are developing for showing coefficient of correlation between two subjects.

Mr. Foberg presented four suggestions for consideration. Each with the action taken by the Section is given:

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1. The Section should have a cooperating committee for the coming year. Same committee was continued.

2. There should be one year of required mathematics for every boy and girl. Discussion: The Section seemed to feel this a lowering of standard until reports showed many schools where no mathematics is required. Final action was not taken.

3. Steps should be taken by Section to bring about revision of college entrance requirements. Discussion showed that students who have had only one year of mathematics try for exams for which prerequisite is two years. Also college entrance requirements in one section of the country dominate requirements for the whole and form an insurmountable difficulty to improvement in mathematics teaching. Work was referred to the general committee at the suggestion of Miss Sykes.

Mr. Comstock's motion carried: That the Publicity Committee take steps to spread the findings of the Committee on Requirements before superintendents and principals at their meeting and in whatever other way they deem possible or advisable in conference with a similar committee of the American Mathematics Association.

4. The actual condition in regard to findings about formal discipline should be spread abroad. The Section approved the suggestion and asked to have information sent to others than mathematics people as well as to those naturally interested.

Committees appointed: Nominating Committee—Mr. Cobb, Chairman; Mr. Davis. Committee on Finance—Mr. Comstock, Chairman; Mr. Crandall, Miss Hunt.

Saturday Morning Session.

The Saturday morning meeting was addressed by Mr. S. A. Courtis, Supervisor of Educational Research, Detroit, Michigan, on "Measurement of Products of Teaching High School Mathematics."

In the discussion which followed, valuable suggestions were given as to tests which teachers could make at the present time. Reference was made to the book, "Educational Tests and Standards," by Walter S. Munro (published by Houghton Mifflin Company).

The report of Committee on First Year Mathematics was submitted, briefly discussed and referred again to the committee for completion, with the suggestion that copies be put in the hands of every member of the Section and each member send in suggestions as to changes.

Committee reports: Nominating Committee, Mr. Foberg, Chairman; Mr. Crosby, Vice-Chairman; Miss Atkin, Secretary.

Ballot ordered cast by Secretary.

ETHEL JAYNES,
Secretary pro tem.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION MEETING OF DECEMBER 20, 1917.

The nineteenth semi-annual meeting of the Southern California Science and Mathematics Association was held on December 20, 1917, in the science building of the Manual Arts High School, Los Angeles, Cal.

Only one afternoon was given to the general session as well as the Section meetings, as the Association meeting was held in connection with the combined institutes of the Los Angeles City and county. These furnished a large and varied program continued throughout the week of December 17 to 21. About a hundred members were present and a very interesting and profitable program was enjoyed.

The chief speakers on the program were Dr. Babcock, who has been associated with George Ellery Hale in his work on the Council of De-

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fense, and Professor Laird Stabler of the University of Southern California, a recognized authority on petroleums. Their subjects, "Science and the War" and "Synthetic Gasoline" give some indication of the interest with which they were received by the audience.

At the business meeting which followed, the following officers were elected for the ensuing year.

President—Miss Agnes Wolcott, Long Beach High School.
Vice-President—Prof. E. E. Chandler, Occidental College.
Secretary-Treasurer—Miss Harriett S. King, Pasadena High School.

The following officers were reported elected at the meetings of the various Sections:

Mathematics Section.

Chairman—Prof. Paul Arnold, University of Southern California.
Secretary—Mrs. E. C. Farnum, Manual Arts High School, Los Angeles.

Earth Science Section.

Chairman—Mrs. Helen V. Peasley, 14th St. School, Los Angeles.
Secretary—Miss Minnie Reed, Berendo Int. School, Los Angeles.

Biology Section.

Chairman—L. R. Longworthy, Manual Arts High School, Los Angeles.
Secretary—Miss Grace M. Abbott, Venice High School.

Physics-Chemistry Section.

Chairman—A. Haven Smith, Riverside High School.
Secretary—C. W. Gray, Hollywood High School.

CLASSROOM SAYINGS.

THE ZOOLOGIST'S REQUIEM.

Oh, when I die don't bury me at all,
Just pickle my bones in alcohol.
Put a bottle of ——— (formalin) at my head and feet,
Then leave me alone, I guess I'll keep.

—[Anon.

"Kerosene emulsion is used for cleaning the carpet beetle and washing the floor so that they might not appear. It may be used for cleaning bedbugs also."

"Ichneumon fly is a parasite living on caterpillars. It stings the caterpillar and stays with its head buried until the caterpillar is dead."

"Beeswax is made by the workers. When the workers eat a lot of honey they sit still for a long time and wax forms in their wax pockets."

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for December; *5648 Kenwood Ave., Chicago; $3.00 per year:* "Cavalieri's Theorem in his own Words," George W. Evans; "Mathematical Forms of Certain Eroded Mountain Sides," T. M. Putnam; "The Obsolete in Mathematics," G. A. Miller; "A Substitute for Dupin's Indicatrix," C. L. E. Moore; "The Work of the National Committee on Mathematical Requirements," J. W. Young.

Geographical Review, for February; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "The Eskimos of Northern Alaska: "A Study in the Effect of Civilization, "Diamond Jenness. (1 map, 7 photos); "The Isolation of the Lower St. Lawrence Valley," Roderick Peattie. (1 map, 8 photos); "Our Waterway Requirements," Robert M. Brown; "Ocean Temperatures Off the Coast of Peru," R. E. Coker; "Some Chinese Contributions to Meteorology," Co-Ching Chu; "New Evidence That Cook Did Not Reach the Pole."

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Journal of Geography, for February; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "A Comparison of Transportation on the Mississippi Basin Rivers and the Great Lakes," A. E. Parkins; "The Nitrate Industry of Chile," W. R. McConnell; "Physiography as a Basis for Commercial Geography, Botany, and History," Alison E. Aitchison; "A Neglected Duty of the Geography Teacher," Hannah Lindahl; "Minneapolis Outline for Teaching Japan and China."

Nature-Study Review, for January; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "The Striped Gopher," E. L. Palmer; "Animal Tracks," Robert W. Hegner; "The Odoriferous Skunk," Wm. E. Ringle; "Winter Sleepers," Editha S. Campbell; "The Snake," G. T. K. Norton.

Physical Review, for January; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Geometry of Image Formation in X-Ray Analysis," Horace S. Uhler; "The Ratio of the Intensities of the D Lines of Sodium," Vivian Voss; "On the Thermodynamics of Fluorescence," E. H. Kennard; "Kathodo-Fluorescence of Crystals," Thomas B. Brown; "The Necessary Physical Assumptions Underlying a Proof of the Planck Radiation Law," F. Russell v. Bichowsky; "On Certain Absorption Bands in the Spectra of the Uranyl Salts," H. L. Howes; "Resonance Radiation of Sodium Vapor Excited by One of the D Lines," R. W. Wood and Fred L. Mohler.

Popular Astronomy, for February; *Northfield, Minn.; $3.50 per year:* "Earlier Photography of the Firmament," Charles N. Holmes; "The Lunar Saros," William F. Rigge; "The Path of the Moon's Shadow," Frederic R. Honey; "Canopus as Seen from Florida," Jennie L. Kyle; "The Total Solar Eclipse of 1918, June 8," Edwin B. Frost; "Cloud Conditions Along the Path of Totality 1918, June 8," David Todd; "Suggestions Concerning the Place of the Zodiacal Light in the Solar System," Rev. W. E. Glanville; "The Principle of the Conservation of Moment of Momentum," F. R. Moulton.

School Review, for February; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Significant Results of Missouri and New Mexico Commercial Education Surveys," Paul S. Lomax; "The Part Time Plan in the Centralia (Illinois) Township High School," Eston V. Tubbs; "The Junior High School—Its Place in the Reorganization of Education," Arthur J. Jones.

School World, for January; *Macmillan and Company, London, Eng.; 7s. 6d. per year:* "Science and Invention," Alan A. C. Swinton; "Considered Suggestions for Educational Reform, Pros and Cons, II."

Teachers College Record, for November; *Teachers College, New York City; $1.50 per year, 40 cents a copy:* "Experiment in Education," Frank M. McMurry; "Experimental Teaching and Its Relation to Elementary Education," Grace A. Day; "The Value of Supervised Study," Grace A. Dunn; "Significant Movements in Secondary School Mathematics," Raleigh Schorling; "Camouflage," Alon Bement; "Some Sugar Saving Sweets for Every Day," May B. Van Arsdale and Day Monroe.

BOOKS RECEIVED.

Textbook of Botany, by Charles E. Allen and Edward M. Gilbert, University of Wisconsin. Pages x+459. 13x19 cm. Cloth. 1917. $1.48. D. C. Heath and Company, Boston.

Principles of Economic Zoology, by L. S. Dougherty and M. C. Dougherty, Normal School, Kirkville, Mo. Pages ix+428+11. 14.5x20.5 cm. Cloth. 1917. $2.00 net. W. B. Saunders Company, Philadelphia.

A Short History of Science, by W. T. Sedgwick and H. W. Tyler. Massachusetts Institute of Technology. Pages xv+474. 15x22.5 cm. Cloth. 1917. $2.50. The Macmillan Company, New York City.

Agricultural Bacteriology, by H. W. Conn, Wesleyan University. Pages x+357. 14x20 cm. Cloth. 1917. $2 net. P. Blakiston's Son & Co., Philadelphia, Pa.

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Fifty Years of American Education, by Ernest C. Moore. 96 pages. 13.5x19.5 cm. Cloth. 1917. Ginn & Company, Boston.

Plane Trigonometry, with Tables, by Eugene H. Barker, Polytechnic High School, Los Angeles. Pages vii+172. 16x23.5. Cloth. 1917. $1.00 net. P. Blakiston's Son & Co., Philadelphia, Pa.

Commercial Algebra, by George Wentworth, David E. Smith and William S. Schlauch. Pages v+266. 13.5x19 cm. Cloth. 1917. $1.12. Ginn & Company, Boston.

BOOK REVIEWS.

Mathematics for Agriculture and General Science, by A. M. Kenyon, Professor of Mathematics, and W. V. Lovitt, Assistant Professor of Mathematics, Purdue University. Pages vii+357. 13×19 cm. $2.00. 1917. The Macmillan Company, New York.

The parts of college algebra, trigonometry, and analytic geometry which are most useful in practical work, both in and out of college, are presented in this volume. It covers a course of three hours a week for one year. The topics have been wisely chosen and clearly discussed. A very large number of problems, including much data taken from agricultural and other experiments, shows the application of general principles to problems which arise in real life. Chapters in land surveying, statics, small errors, compound interest law, probability, and correlation give further real applications. H. E. C.

College Algebra, by E. B. Skinner, Associate Professor of Mathematics, The University of Wisconsin. Pages vii+263. 13×19 cm. $1.50. 1917. The Macmillan Company, New York.

To meet the changes that have taken place in the teaching of secondary school mathematics, and to emphasize the immediately practical side of algebra, this textbook makes some decidedly interesting changes in the traditional course in college algebra. Elementary material is presented from the viewpoint of maturer students and illustrative problems from geometry, physics, the theory of investment, and other branches of pure and applied science lend interest and show the use made of algebra in these fields. The functions which occur most frequently in practical work receive considerable attention. The generous use of geometrical interpretations will aid students in getting a concrete understanding of algebra. H. E. C.

Junior High School Mathematics, First Course, by W. L. Vosburgh, Head of Department of Mathematics in the Boston Normal School, and F. W. Gentleman, Junior Master, Department of Mathematics, The Mechanic Arts High School, Boston. Pages vii+146. 13×19 cm. 75 cents. 1917. The Macmillan Company, New York.

This book gives work in arithmetic for the seventh school year. It includes a review of the preceding arithmetic, equations of the simplest type, measurement, percentage, interest, and areas of simple plane figures. The problem material is selected from situations of interest to the child, and due effort is made to accustom the pupil to the standards of the business world. H. E. C.

Differential and Integral Calculus, by H. B. Phillips, Ph. D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. Pages, Part I, v+162; Part II, v+194. 13×19 cm. Combined edition. $2.00. 1917. John Wiley & Sons, Inc., New York.

In order that the student may learn principles and gain power, a few central methods are set forth and applied to a large variety of problems. By this plan less time than usual is given to differential calculus, leaving

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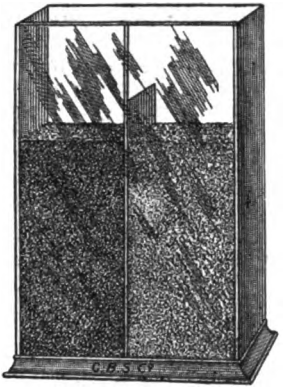

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more time for integral calculus which in general plays a more important part in engineering problems. Throughout the book practical applications are made in close connection with derivation of rules for differentiating and integrating. Lists of supplementary exercises are given at the end of each part. H. E. C.

Some Agricultural Textbooks.

We have received for review five very excellent books of especial interest to agriculturists because of their merit. The books are of course of value to others interested in their fields. It would seem that the field of agriculture is receiving the help of better writers of textbooks than the older departments of biological science—botany and zoology. This is probably due to the spur of the development of a new field.

School Entomology, Sanderson and Peairs, Wiley Technical Series.
Mycology and Plant Pathology, Harshberger, Blakiston & Sons.
Soils and Fertilizers, Lyon, The Macmillan Company.
Productive Agriculture, Gehrs, The Macmillan Company.
Botany of Crop Plants, Robbins, Blakiston & Sons.

School Entomology. It has been estimated that the annual damage from harmful insects in the United States amounts to 1,000,000,000 dollars. This is talking about money in war terms, but it ought to be war terms, war against harmful insects. Books like *School Entomology* are the best of ammunition with which to fight the evil. Knowledge of the problem is the first essential, then study of methods may follow. This book is intended for use in secondary schools, and it is admirably adapted for the purpose, either as a textbook where possible, or as a reference book where time does not permit a more formal use.

It is divided into two parts—general entomology and economic entomology. The authors seem to have been very wise in their selections of what to use and what to omit and, what is of much importance, have not tried to do too much, to bring in too many forms and facts, and thus bewilder the student.

The second part seems to be especially good and is to be commended

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for its clear statements of methods of control and destruction of insect pests. The reasons for the recommended treatment are clearly stated and very helpful. The book is well illustrated. A large number of species of insects are shown in small space by means of photographs. There are 356 pages, 233 figures and plates, size is 13×19 cm., price $1.50 net.

Mycology and Plant Pathology. This book is intended for college use, but will make a very useful reference book for all interested in diseases of plants. Its scope is truly wonderful—we may find anything from the scientific presentation of the morphology, histology, physiology, ecology, and chemistry of fungi to spraying tables showing the same painstaking care in preparation, on the practical side. The book is really cyclopaedic in its scope and variety of topics. We cannot give space here to give it an adequate review, but a list of the divisions or parts into which the book is divided will help give an idea of what it contains. They are: Part I, "Mycology"; Part II, "General Plant Pathology"; Part III, "Special Plant Pathology"; Part IV, "Laboratory Exercises in the Cultural Study of Fungi."

There are extensive lists of specific diseases of plants with references to literature on these diseases. There are also bibliographies for each of the more important topics treated. The descriptions of diseases are concise and clear, and each is accompanied with directions for control or treatment. There are specific directions for making the various spraying compounds with hints as to their use and references for more detailed instructions. Pages 779, figures 268, size14×19 cm., price $3.00 net.

Soils and Fertilizers. This is a book that can be recommended without reserve within its field—the secondary school. The presentation, arrangement, and balance are all good. The paragraphs are short and to the point. It is broad in its viewpoint and very practical in many ways, fitting the teaching to the farm's actual needs.

There are abundant laboratory exercises with each chapter, and a set of questions whose aim is to develop thinking. There are helpful illustrations and tables. Pages 255, figures in text 34, plates XVI, size 13×19 cm., cost $1.10.

Productive Agriculture. This book is designed to meet the need of elementary school agriculture—for seventh and eighth grades. Probably it would be better fitted for ninth grade work of the high school, where agriculture is given in this grade. The book is very carefully written by one who evidently understands what is needed for these grades of students. Its treatment of the topics is not childish and even silly as is the case very often when authors try to write science textbooks for young people.

The topics are well chosen and we must specially commend the last section on farm management, covering the choosing of the farm, planning a farm, farm bookkeeping, farm labor, and animal husbandry from the management point of view. These are very important divisions of the subject, and it is in these departments that most farmers fail when unsuccessful.

We do not approve the order in which the topics are arranged. The order is crops, animal husbandry, soils, plant propagation, and farm management. The fundamental things are the plant and the soil and their relation to each other. We believe that young people appreciate a logical development of a topic as well as older people, in fact it is more important that the topics be presented in their right relation with each other. We also find that a really fine presentation of the topic of soils is made without even a hint that a plant has such a thing as a root! In fact the plant as a living thing is wholly omitted.

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There are abundant tables of statistics where needed and laboratory exercises with each chapter. The illustrations are particularly good. Pages 436, figures 186, graphs 18, numerous tables, size 14×17 cm.

Botany of Crop Plants. This is a college textbook and of course has no use as a secondary school textbook, but as a reference book it will be invaluable to teachers of modern botany and agriculture. Part I, including the first seven chapters, treats of the fundamental structures of plants, and Chapter VIII, the classification of plants. Part II begins the real work of the book, the botany of crop plants by families, beginning with the Gramineae. Thirty-two families of plants are taken up in as many chapters. The author has had in mind nonagricultural as well as agricultural schools on account of the modern tendency to tie the subject up more closely with economic interests.

The treatment of each crop plant is very complete, including the habit of the plant, the flower in detail, the grain (if a cereal) in detail, classification of species and varieties with their characteristics, origin, environmental relations, uses, production, and finally a bibliography. It will be seen that a book of this sort must be an exceedingly useful book for the teacher of botany and agriculture in secondary schools who wishes to illuminate the daily work with something more than the textbook in use may give. Botany teachers especially must realize that their subject must be more closely allied with the practical affairs of life, the more so as it can be done in this case without taking anything from the scientific value of the work in botany—if the teacher understands both botany and agriculture.

There are 683 pages, 263 figures in the text, size 14×19 cm., and the price is $2.00 net. W. W.

Comparative Anatomy of Vertebrates, by J. S. Kingsley, Professor of Zoology in the University of Illinois. Second Edition, revised, with 406 illustrations and 449 pages. 15×22 cm. $2.50 net. P. Blakiston's Son & Company, Philadelphia.

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This revised edition has been largely rewritten and carefully revised. We do not need to say anything about the merits of such a well known and standard college textbook. It is a fine specimen of bookmaking, especially in the matter of illustrations, which are largely original. To one wishing work in this line the book should be indispensable.

W. W.

Animal Micrology, Practical Exercises in Zoological Micro-Technique, by Michael F. Guyer, Ph. D., Professor of Zoology in the University of Wisconsin. Revised edition, with 74 illustrations and 289 pages. 15×22 cm. $2.00 net. The University of Chicago Press, Chicago.

This second edition of this well-known book has been revised to bring it up to date so far as possible, by incorporating the most important of the many new methods of technique being constantly developed by students of zoology. Such a book as this is needed, but most of all it needs to be up to date to be of greatest value. There are two new chapters added in this edition, one on "Cytological Methods" and one on "Drawing" by Dr. Elizabeth A. Smith.

The aim has been to give space for only the most important methods, for the number of methods is legion. There are several appendices, one of the most important of which for the student user is a "Table of Tissues and Organs with Methods of Preparation." This should be a very time-saving help for the student.

W. W.

Microbiology, a Textbook of Microorganisms, General and Applied. Edited by Charles E. Marshall, Professor of Microbiology, Massachusetts Agricultural College. Second edition. 186 illustrations. Pages 899. 14×18 cm. $3.00 net. P. Blakiston Son & Co., Philadelphia.

This book is a compilation by twenty-five experts on microbiology, each contributing an article on the topic with which he is most familiar. Microbiology takes in such a wide field that some such plan as this is necessary to cover it satisfactorily. It is impossible in the space at command to give any adequate idea of the topics covered by the book. Diseases of man and domestic animals occupy only one-fourth the space. Some of the other topics treat of microbial diseases of plants, of insects, of special industries, of milk and its products, of the air, of water and sewage, and of the soil. Parts I and II take up the morphology and culture of microorganisms and their physiology.

It should be a valuable source book for anyone interested in the subject, and especially for the secondary teacher of physiology.

W. W.

A Textbook of Botany for Colleges, by William F. Ganong, Ph. D., Professor of Botany in Smith College. Part II, pages i-ix and 391-595, with 125 illustrations. 13×18 cm. $1.00. The Macmillan Company, New York.

This second part of Dr. Ganong's textbook completes the work begun with the first part on the "Structures and Functions of Plants." It is designed primarily for those students who take a course in botany as a part of their general education. The treatment is general rather than technical, details being largely omitted. As the size of the book indicates, much had to be omitted, but the emphasis is on the natural history side rather than the morphological details.

Part II includes the "Kinds and Relationships of Plants." Each of the great groups and their classes is taken up for discussion in order, beginning with the thallus plants. The style is clear and simple as always by this author. The illustrations are good, especially the life cycles.

W. W.

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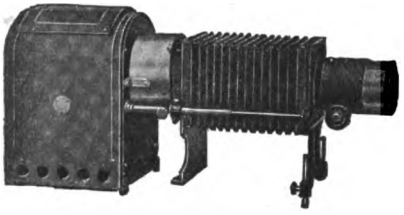

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, NO. 4 APRIL, 1918 WHOLE NO. 150

REASONS FOR GIVING GEOGRAPHY A GREATER PLACE IN THE HIGH SCHOOLS.[1]

By GEORGE D. HUBBARD,

Oberlin College, Oberlin, Ohio.

Introduction.—Let us be perfectly clear at the start that this discussion is based upon geography for the high schools, not upon such special phases thereof as physical or industrial geography. I look upon geography as (1) a study of locations and distributions of both human and environmental items and (2) a study of relations between the items of these two categories. In the words of another writer "Geography is the study of the mutual relations between man and his surroundings."[2]

When the emphasis is particularly upon locations and distributions, the work is especially memoriter. When the stress is laid upon the relations existing between form and form, or between forms and man, the work is more largely reasoning. Both phases are informational and both are disciplinary.

I agree with most of the teachers that pure physical geography or physiography is not at home in the high schools. It has been there because both the makers of textbooks and the teachers came to their geography by the geologic route and naturally emphasized that material most familiar. I also agree with my fellow-workers that industrial geography is too specialized to find a healthy atmosphere outside the technical high schools. Both subjects may be retained as electives in a high school, but they should not be considered substitutes for geography any more than bookkeeping should substitute for algebra or general science for physics and chemistry.

I have no apologies to offer for being here, nor for being the advocate in this case. I was delighted to be drafted for

[1]Read before the Earth Science Section Central Association at Columbus, Ohio, December 1, 1917.

[2]J. F. Chamberlain, *Jour. Geog.*, Vol. 5 (1906), p. 369.

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this purpose, because I believe fully in geography, humanized and vitalized as it is today. I believe it can and should play a large part in secondary education. I am convinced that it has strong disciplinary value, and I am equally sure it has real cultural value. Add to these two its primary and obvious everyday utility and you see the main reasons why I believe teachers and geographers should be enthusiastically in favor of geography in the high schools. In preparation for this paper, I have used the German method of much thought on the subject, the French method of much reading, and the English method of much personal experience with the subject. I have borrowed freely from my contemporaries and I pass on to others just as freely. If I shall be able to make my case clear to most of us here, my appearance shall not be in vain.

I want in the space allotted me to set down some of the reasons for my convictions and beliefs stated above. These reasons may be grouped under the three subheads mentioned, utilitarian, disciplinary and cultural.

1. *Reasons Based upon Its Usefulness.*

Recognized as Fundamental in Grades and Advanced Studies.—In the words of Miss Kirchwey of Columbia: "Those who know the nature and value of the subject and the capacity of pupils are unable to understand why geography is so nearly limited to the elementary grades."[3] Dodge[4] and Whitbeck[5] both give expression to this idea in a different way. Dodge calls attention to the fact that pupils entering college are found short in geographical information and raises the question, "How can they help it, no matter how well they are taught, for they have had nothing, or very little, in this field for four or five or even six years before they enter college?"

That lost interval is one of rapid growth and adjustment, when the old is thoroughly displaced by new habits and methods of thought and by new attitudes toward life. We want the freshman in college and the high school graduate in business to be keen in English, mathematics and history, so we keep him at all three during the high school course. We deplore his ignorance of geography and yet we drop it out of his course after three or four years in the grades. What knowledge of English or mathematics would our people have at the college or business

[3] *Jour. Geog.*, Vol. 14, p. 291.
[4] *Jour. Geog.*, Vol. 5, p. 79; vol. 6, p. 102.
[5] *Jour. Geog.*, Vol. 14, p. 65.

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door if they abandoned the subject when they left the seventh grade? Training in geography should begin in the grades and continue through the high schools as do mathematics, history and English, that pupils may know the subject when they graduate.

Those who study no regional geography after the grades are inadequately prepared either for further school work or for life. That this is true is attested on every quarter. Business men complain that the young people in their employ do not have geography when they come. Normal schools say their students do not have geography enough to take on the best thought and experience in methods of presenting the subject, so geography itself must be taught here before its pedagogy. The college teacher in every department notes the lack of geographic knowledge and training in his pupils.

Whitbeck raises the question: "Why is the study of geography made one of four or five fundamentals in elementaryschools of every enlightened land?" Its use and need are almost universal and it should rank as one of the fundamentals. Why is it dropped out years before the others go?

Teaches the Uses and Language of the Map.—Another phase of the utility grows out of the fact that geography's chief representative material is the map in which is condensed and recorded such a wealth of information not only geographic, but historic, economic, demographic, and political. Many a man in every walk of life has never learned the language of the map and all the world's knowledge stored in the various classes of maps is closed to him. "The ability to use maps and atlases and the habit of turning to them is one of the most valuable possessions which a course in geography can give."[6] It certainly seems unfortunate that so large a percentage of our men and women should be shut out of this treasure house because they do not know well its language.

Helps to Meet and Solve Daily Problems.—Another writer points out[7] that "no one can successfully cope with the world problems of trade and industry unless he has adequate knowledge of the various lands, their resources and development." A consideration of man's distribution and of his development and occupations in the different types of geographic conditions reveals abundant evidence of his ready response to intimate relation with the environmental conditions, climate, soil, relief and

[6]Chamberlain, J. F., *Jour. Geog.*, Vol. 5, p. 373.

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resources. The needs of civilized man make requisitions upon all regions of the world. The more and better knowledge he has of these regions the better equipped he is to draw upon their varied resources. Shall the men and women of the next generation be able to meet successfully the great problems of life, industry, nationalism and internationalism? Then teach them as children and growing young people the value and distribution of resources, the relation of region to region as dependent upon national resources, climate and connections, the relation of people to people and product to product as determined by the geographic conditions. Teach them the inter-relations of nations and the interdependence of regions and let them come to realize that real "life is the establishing of equilibriums with the environment" as Herbert Spencer said. This emphasis is strongly placed in the Indianapolis course of study. Why not give the lad all possible help in understanding the environment and its relations to man; in linking himself up in a healthy, practical way with that which surrounds him and upon which he depends, and thus make it possible for him to live the largest, best and most civilized life?

Lincoln Hutchinson says:[8] "Man's very existence depends upon the geographical phenomena with which he is surrounded. Geography is an interpretation of these phenomena in the light of man's activities." Sutherland[9] points out that the history of nearly every localized industry shows it to be tied to its geographic factors of distribution, raw materials, markets, climate and labor, and that the "trend of industrial history is determined by geographic conditions." The best economists work on this conception. All trade and commerce is based on differences in resources and products. One should know a large body of these differences in resources and products to enter successfully into business competition. Such familiarity with geography helps one to see into the possibilities for his own country and the ways to meet the needs of his own nation or his own business, as well as indicating points of contact between his own and other nations. These points may or may not be developed. Many of these sentences are given added weight when one realizes that our young people, if they do as other generations have done, will soon be the established men and women of the land, and will have the large places in the world.

[7]Gulliver, F. P., *Jour. Geog.*, Vol. 5, p. 468.
[8]*Jour. Geog.*, Vol. 6 (1907), p. 127-8.
[9]Sutherland, W. J., *Jour. Geog.*, Vol. 5 (1906), p. 123.

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What would it mean to the industrial, commercial, political, and professional development of our beloved land if everyone entering had a keen geographic vision, a good understanding of the significance and workings of these geographic factors! According to facts disclosed by the recently published draft figures, 1,000,000 men turn the age of twenty-one every year. Certainly as many pass eighteen, the age to graduate from high school. These men are in all walks and fortunes of life. But suppose each of these who went through high school, say a quarter million a year, received there a good, sound, geographic training, as good of its kind as that given him in mathematics and English. What a grip those young men could take on affairs! What a vision of the inter-relations and interdependence of men! How they could lead off in the affairs of men! Of what untold value their knowledge and power might be! Then suppose all of these men for twenty-five years actually did go through high school and really did receive such geographic training. Wouldn't America have a vision? And wouldn't American industry stand forth? But hush! It is a great dream! We can't do it now. Isn't it worth working for?

Geography Among Other High School Subjects.—There are other utilitarian values in geography. The New England Association of School Superintendents is responsible for the illumination shed by the following statement: "As a source of information valuable in itself and not merely as an instrument, it (geography) has no equal among its associate subjects."[10] The same group of teachers also urges that pupils "gain such knowledge about the earth and its inhabitants as shall make us know the world we live in, both as to the *land* on which are spread out the nations, and the *people* with their varied means of providing for their continual, essential and universal wants." It is particularly of its relation to other high school and college subjects that I want now to speak. A. T. Olmstead[11] says: "There is no science which has added more to a proper understanding of history than geography." Fenneman[12] says: "Regional geography of all phases of earth studies is best fitted to be a basis for entrance to college." And he further points out that it has a very valuable reflex influence on elementary geography; first, because so many high school graduates become grade teachers; second, because the high school pupils later

[10] *Bull. Am. Geog. Soc.*, Vol. 33 (1901), p. 441.
[11] *Jour. Geog.*, Vol. 10, p. 163.
[12] *Jour. Geog.*, Vol. 7 (1908-9), p. 156.

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become school boards and intelligent members of the community. Geography is considered by some as preliminary and introductory to other sciences, by some as a synthesis of several subjects and hence competent to succeed them. It may be made either or both. Here are two excellent reasons for giving it in the high school. One argues for a Freshman treatment, the other for a Senior place.

I want to go farther in this matter of geography among its contemporaries in the secondary school curriculum. Its importance as the foundation and directing influence in the history of men and nations has already been stressed. National and racial as well as industrial history have been shaped by geographic conditions. No geography to illumine history in the high school means weaker and less effective history work. Closely related to history are civics and political economy, both of which are much better understood when interpreted with a geographic background. Why not teach the coming citizens to interpret each nationality in terms of its varying environment, with its limitations and possibilities, thus opening the way for appreciative and sympathetic brotherhood?

Botany and zoology always find their materials in certain geographic environment. If the course is to live, to be more than taxonomy, the geographic element is indispensable; and should the subjects take the very practical ecologic turn, the geographic at once comes to be uppermost. Literature and the foreign languages, Latin, German and French, fall far short of their inherent possibilities if not vitalized by uncovering wherever possible their geographic settings. Agriculture is a geographic subject, its distribution, methods, and success are distinctly dependent upon geographic (including climatic) conditions. One has but half his agriculture if he omits the geographic connections. Even the frills and trimmings of the high school program, most of them altogether practical, art, manual training, domestic science, and other hand work, should have their geographic contacts noted. From where do the materials come? Their qualities, prices, and utility are products of their places of origin, distance from market, and the conditions under which they are used.

Geography and College Subjects.—One has said: "Perhaps no study outside the mother tongue is vitally connected with so many college studies as geography."[13] Beginning with college

[13]Fenneman, N. M., *Jour. Geog.*, Vol. 7, p. 156.

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geography, which should have the best possible elementary geographic foundation, those so connected are history, economics, sociology, political science, biologic science, agriculture in many of its phases, engineering, architecture, forestry and Bible.

Working out the relations a little farther, by quoting from a recent paper it may be said that "the physical features, climate, mineral and agricultural resources have furnished one motive in all history; topography, distribution of land and water, plain and mountain, valley and barrier, have been another; and the approachableness, proximity, or isolation of nations a third. While in most of ancient and medieval history, nations have concerned themselves with defense and military aggression, in the future they will be interested with the things that make for peace and mutual advancement. American, European and Oriental history are each intimately related to their respective lands; in fact, have been unfolded in specific localities under the influence of specific physical conditions.

The Oriental problem grows out of a chronic and aggravated case of geographic isolation, and breaking the isolation is already helping to solve the problem.

Race and immigration questions have to do with the sources and destinations of our immigrants, but that is not all. The character of the immigrant, the nature of his former home and his usefulness in the new are in large part geographic. He moves because of overcrowding or insufficient opportunity. He goes where physical opportunities seem to be greater. Transplanted, he finds new conditions and is uncomfortable and more or less a joke or a menace in the new place until adjusted.

Soils are a part of the physical environment to which geographic responses are made; hence a good understanding of geography will go a long way toward interpreting the soils. An appreciation of the geography of the various agricultural regions of the world would be an excellent basis for a study of comparative agriculture and would be an illuminant of the history of agriculture.

In summarizing the relations between geography and the subjects studied in colleges and universities it is sufficient to say this field is the meeting place of the physical and the human sciences. Their circles meet or overlap in geography and while each subject may contribute to the latter, each also draws from it fundamental material for further work in its own line.[14]

[14] *Educational Review*, 1908, pp. 388-90.

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Helps to Interpret Human Affairs.—Dodge[15] says: "Geography is of value in the interpretation of human affairs, in making clear the story of the past and the conditions of the present." One does not need to study all of the data, theory, and philosophy, of the geography of every land to arrive at this value. This science lends itself admirably to the project or problem method as McMurray has indicated in his "Type Studies in Geography." In biology, we do not study all animals, not even all species, genera, families or orders. We select eight or ten types and study them in detail, then generalize. In geography, choose out many type countries, some of the first order as Great Britain, Russia, France, United States, Germany and China, and some of the second order as Austria-Hungary, Argentine, Brazil, Belgium, Holland, Japan, Italy, and study each intensively, then the minor countries could be used as outside reading to be compared and contrasted briefly with the types.

This geography will lead pupils to appreciate the physical, economic, and social causes underlying the consequences seen in human life. The youngster needs as a part of his equipment "a definite idea of the resources of his country, an idea of their value, distribution and relation to the various occupations, and to sense the fact that the life of a nation is due directly to its resources."[16] It will help him to understand the modern talk about conservation as nothing else perhaps can. Miss Henderson says on this point:[17] "Geography supplies a large share in training boys and girls into broad-minded, honest, sympathetic, clear thinking men and women, able to see plainly and to meet face to face the problems of national and private life . . . and to go about their solution in a sane, unprejudiced manner." And she adds at a later date: "When the great importance of wheat, iron and coal is clearly understood it is not hard to stimulate the thought that the producers (capitalist, boss, and laborer) are worthy of consideration; that their health, intelligence, and general comfort are important factors in the equation of production; and that conservation of exhaustible resources is a question of world-wide significance."[18]

Whitbeck,[19] speaking of geography in general and again of economic geography, puts it very suggestively. He says the "mission of geography is to give the broadest possible knowledge

[15]Dodge, R. E., *Jour. Geog.*, Vol. 14, pp. 282-3.
[16]Gregory, J. W., *Jour. Geog.*, Vol. 8, p. 113.
[17]*Jour. Geog.*, Vol. 8, p. 129.
[18]*Jour. Geog.*, Vol. 14, p. 98.
[19]Whitbeck, R. H., *Jour. Geog.*, Vol. 14, p. 70; Vol. 15, p. 233.

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of peoples, countries and their cities, of their industries and achievements, and all that goes to make them weak or strong, leaders or followers among the nations of the earth and the principal reasons why these things are as they are." A year later he wrote, "it (economic geography) consists in part of the practice of sizing up the various relations of the world . . . in gaining an appreciation of their agricultural and mineral resources, the peculiar genius of the people, the strength or weakness of their governments, the efficiency of their education, their nearness to other countries whose trade is profitable, their access to the sea . . . and their defense against enemies . . . a sort of character study of the nations, it will (thus) be one of the most valuable studies in the curriculum. Every educated person desires this sort of knowledge." He further suggests, as an inspirational method of teaching, the use in review of a sort of score card upon which pupils could record their estimates of the various items in a nation's geography, nation after nation, so that they could be ranked or rated as are dairy animals or draft horses. A unique and capital idea.

2. *Reasons Based Upon Disciplinary Values.*—Geography shares with all the work of the schoolroom in the training of memory. From this point of view there is probably no more reason for teaching geography than any other subject. But the very fact that this subject is synthetic, that it brings together data from several fields, makes it of special value in other kinds of mental exercises. There is in every lesson the correlation of facts from different sources and the comparing and contrasting of countries, cities, conditions and results. Then there is the use of reference material, the taking of evidence, weighing, sifting, sorting and testing of evidence, the judging of values of influential factors in the growth of cities, industries and nations, and always the drawing of conclusions from facts observed or discovered on map or printed page. All this is of prime importance in developing the thinking and reasoning powers. Habits of observation and comparison, reasoning and judging, are just as valuable for the college student as for the business man who has never been to college.

A study of geography calls for the making of mental pictures. The home neighborhood can be observed and studied, then seen in map or picture. Then the map and picture of the distant scene is examined and the imagination fills the picture. I have heard lectures on foreign lands by men who have never seen the

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lands themselves, lectures which were so true to the facts and so vivid that travelers who have visited those lands were sure the lecturer had seen all he told. The imagination had been trained to fill in consistent details and produce a true picture. The speaker was a geographer.

Geography lends itself admirably to the scientific method and to the problem or project method of instruction. It permits the setting of problems to be solved both out of doors and in the laboratory.

Education is designed to give both knowledge and power. The educated man has not only a well informed mind but a well trained mind. Geography, on previous pages, has been shown to be competent to furnish knowledge of an extremely valuable kind, knowledge that is not only life giving but life saving, knowledge that can be used every day, knowledge that cannot well be dispensed with. And now it appears also to be able to furnish training that gives power. It is no longer necessary to go over mental exercises in abstractions or with unusable data to get the discipline. One can get all the discipline necessary and at the same time become familiar with some of the most useful and most interesting data the world affords.

3. *Reasons Stated in Cultural Values.*—We come now to some of the more intangible but none the less real values derived from the study of geography. The students in this field have recognized the new, broader conceptions derived from geographic study, and teachers and parents have watched with interest the unfolding sympathy for and fellowship with other peoples as the knowledge of their geography grows. We feel very differently toward the Eskimo with his greasy, dirty skin when we come to appreciate the culinary, dietary and lavatory restrictions his meager, indifferent soil and uncongenial climate put upon him. And we can sympathize much better with the styles of dress and ornament, with the habits of labor and degrees of endurance common to the Central African when we become familiar with his geographic conditions.

Breadth of Outlook.—Some things we read and think about seem to restrict our vision and draw us back within ourselves. Not so with geography. Even if a man or woman never enters any occupation in which he can use his geographic knowledge and facility to make a living, he can see far more clearly than without the geography. This may be because it deals with people and their activities, the things the people are interested

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in, or because it presents to one's mind the affairs of men, or possibly because it deals with objective things. How much more intelligently and broad-mindedly one reads his newspaper, magazine or summary of the world's doings for the week if he brings to his reading a knowledge of the people and places mentioned. How much better able he is to judge of the value of his news, or to estimate the effects of new turns in the politics and affairs of other nations. How much more these various campaigns of the last three years mean to the man or woman who knows about the countries being trampled over and war torn. The geography pupil has indeed a wider outlook than he who has no geography.

Geography Will Make World More Real.—Many people have little or no conception of any other part of the world than their own. In fact, a foreign land lacks reality. They are like the Virginia lad of fourteen who once went with his father on a business trip to the adjoining county and who on his return told his admiring schoolmates that if the world was as big the other way as it was the way he went, she was a buster. I once found a student in a normal school—I trust she was the only such one I ever had—who at the age of seventeen or eighteen confessed she had "never seen any of the surface of the earth." And I heard a bright girl in the fifth grade geography class say that "when ships, sailing the ocean, came to the equator, the passengers all had to get out and walk across and take another boat on the other side." It seems to me one must be fearfully cramped in his perception not to know these common things. Surely geography study will help wonderfully to make foreign lands living realities and the world a peopled home pulsating with familiar activities.

Depth of Interest.—One's interest in good things increases with his knowledge of them. Geography tends to socialize us all as it does the curriculum of which it is a part. It makes our conversation about things and affairs more interesting and intelligent. A man cannot well become self-centered if he has a working knowledge of the places and activities of the world, and of the life, feelings, inspirations and limitations of many groups of his fellow-men. His interests, too, will be broad. Intelligent, everyday, sane, healthy living demands geographic knowledge. And in turn this knowledge will give one lofty conceptions of life and some realization of his privileges and obligations among men.

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Makes Sympathies More Cosmopolitan.—There seem to be people about us who have no sympathy or feeling of fellowship and kinship for any foreigner, but those of their own race, and I find that many of these unfortunates do not know much about the other fellows, know nothing of their geographic conditions, climatic limitations, handicaps of location, means of communication and travel, lack of resources and hindrances to development. I am sorry to have to state, but I believe it is true, that many a missionary to the Orient has done but small good because of lack of knowledge and sympathy. Geographic knowledge brings a pupil into close sympathetic touch with human life in every land, and thus becomes a powerful factor in true education and culture. Geography fraternalizes races and nations. It reveals the conditions under which the other fellow works and has developed, and thus helps us to understand him. His achievements look different in the new light, likewise his peculiarities. Miss Kirchwey believes "our geography or lack of it is largely responsible for our attitude toward other peoples."[20]

Geographic Knowledge Removes Prejudice.—Perhaps this point should have preceded the last, but it is certainly suggested by that and so may logically follow. In my early school days I found a geography which was then many years old. In it were picture maps. The map of Africa had in its central part a picture of men with tails, and that of Asia, men without heads, in Kamchatka and northern Siberia. It had many other strange and weird things in the *terra incognita*. Such a book developed my prejudice. I was terrified by some of the things, amused by others, but I did not care to call any of those deformed or misformed creatures my brethren. I never thought of any of them as having anything to do, as eating, climbing, becoming tired, searching for truth and aspiring to better things as I was doing. But later reading of more modern books dispelled my prejudice, partly by banishing my ignorance and partly by leading my imagination to right conceptions of what these far away lands really contained. I have a profound sympathy for men who can't get my point of view because their conditions have been so different. It is not the pupil's stupidity half as often as it is his environment that keeps him at the foot of his class. Another phase of this question comes to my mind. Some people today seem to be superstitious. One would almost think the thousands of years and scores of generations of ex-

[20] Kirchwey, C. B., *Jour. Geog.*, Vol. 14, p. 297.

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perience would get it out of us. We are not only prejudiced against our fellows, but out of touch with the Infinite. We seem to be unable to comprehend Him and His relations to us. A friend of mine once said: "The pupil may discover through his geography lessons that adjustment to nature is valuable, that harmony with nature is as essential in the physical world as agreement with nature's God is in the spiritual world."[21] I wonder too if he might not learn the other truth, that if adjustment and harmony are so essential in the natural world how much more so they must be in the spiritual.

Stimulates Desire for Travel and Travel Reading.—It has been shown that good geography teaching gives a pupil the use of maps and atlases. It may also teach him the library habit for magazines, papers, reports, books and bibliographies; sources of information. It certainly will make reading more satisfying and intelligible. Even place geography can help in this item. Many a time my students have stopped after class or called at other periods to talk something over and have exclaimed, "How I would like to see this or that!" With the geographic knowledge, they want to see the country and people as well as the canvas and pillars. Some have to do their best to satisfy the wanderlust by reading travel books and descriptive matter; and several have actually found the means to gratify the desire for travel kindled in the geography classes.

Makes for Good Citizenship.—It has been said that "a knowledge of place and regional geography is what the average person, no matter in what walk in life, most needs." A committee on secondary school geography reported the above statement to the National Educational Association in 1909. The report continues: "Farmer, fruit grower, stockman, miner, promoter of railroads and waterways, manufacturer, shipper, fisherman, artisan, health-seeker and traveler all feel its daily need. One cannot read with intelligence the daily papers and periodicals, not to mention history, literature, politics and religion, without some considerable knowledge of regional geography. Familiarity with the geography of our own country and of Europe is a much-to-be-desired factor in good citizenship. Geography touches and broadens the daily life of every individual." However sweeping the above may be, it is certainly true that geography gives a more enlightened citizenship. Goode,[22] in speaking

[21] Sutherland, W. J., *Jour. Geog.*, Vol. 5 (1906), p. 126.
[22] Goode, J. P., *Jour. Geog.*, Vol. 15, p. 274.

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of this regional knowledge of the resources and industrial achievements of peoples, said: "No other study offered in school or college is better adapted, when properly presented, to give an extensive acquaintance with the current history of the industrial world, and this in itself is a large element in a liberal education." I firmly believe there is no one subject so full of possibilities in promoting a healthy spirit among men, in opening one's eyes to the real situations in the regions of the world, in other words, in broadening, enlightening and vitalizing one's citizenship as geography."

If a student goes to college, I suppose one can excuse his high school work by saying "He will get it in college." But what about the ninety in a hundred who never attain to college, and the nine in ten going to college who, under an elective system, do not get geography there? This makes the call for good, clear, sane, abundant geography in the secondary school more imperative. Most of the young people must get it there if anywhere.

Professor Richard E. Dodge, President of the Association of American Geographers, says "Geography will come into its own when it is proved to be worth while."[23]

I trust my effort today will add a little to the proof that has been accumulating in recent years.

[23] *School and Society*, Vol. 3, pp. 253-4.

WAR SAVINGS.

"War Savings Stamps mark an epoch in our national life."—[Secretary of the Treasury McAdoo.

Many a successful business man has said that the saving of his first dollar was the most important single act of his life; that it marked the beginning of a habit and a course of conduct to which he attributed his success.

Something very analogous to this, it is believed, is going to be the effect on the American nation of the War Savings campaign. Not only are millions of individual citizens going to begin to save, but this habit of economy and saving is going to be a collective movement, a movement not of individuals alone but of the nation.

The habit of saving formed now has a deeper incentive than ordinary. We are saving now not alone for selfish reasons, we are saving now from patriotism, saving not alone for ourselves but for our country. The combination of patriotism and thrift is, indeed, going to make the War Savings campaign an epoch in our national life. It is not only going to be a thing of tremendous benefit to millions of citizens, it is going to be a thing of tremendous advantage to the nation as a whole, and affect our whole national life. It marks the beginning of a new era in American life, an era of economy, good sense, and patriotism.

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A QUEER MISTAKE.

By G. A. MILLER,
University of Illinois.

Recently a teacher who was using the Stone-Millis Geometry as a text-book asked me where she could get some information in regard to the Egyptian unit of measure called "ruth," stating that her students became interested in a problem relating to the area of a triangle the lengths of the sides being expressed in terms of "ruths." I naturally did not recall having seen the term but we examined the tables of units of measure found in Eisenlohr's translation of the work of Ahmes without meeting any word which could reasonably be translated "ruths." The indexes of mathematical histories did not supply us with any clue relating to this term.

On looking over the problems in Eisenlohr's Commentary on Ahmes we found on page 125 the following problem: "Wenn dir gegeben ist ein Dreieck von Ruthen 10 an seinem Schenkel, Ruthen 4 an seiner Mündung (Basis). Was ist sein Flächeninhalt?" This problem furnished the key to the solution of the mystery. The authors of the Stone-Millis text-book had evidently failed to see, or followed one who failed to see that the German word "Ruthen" or "Ruten" means rods, and had written "ruths" instead of rods in their translation of this problem, found on page 199 of their *Elementary Geometry*, 1910. This note aims to save other teachers a similar embarrassment. The Egyptians had no unit of measure known as a "ruth."

It should be added that the same incorrect translation of the German word "Ruthen" appeared also in Cajori's *History of Elementary Mathematics*, 1896, page 44, and is repeated in the so-called "enlarged and revised edition" which appeared in 1917. In view of the popularity of this history it seems the more important that this correction should be given publicity, and the fact that the mistake involved is so obvious may perhaps be an element of interest to those who study the history of errors, especially since this error appeared also in other histories of mathematics.

SHORT METHODS IN MULTIPLICATION.

By ROBERT C. COLWELL,
Geneva College, Beaver Falls, Pa.

The multiplication of 111 by 111 gives at once 12,321; of 1111 by 1111 gives 1,234,321; 121 by 121 also gives a symmetrical form 14,641. The 1 of the unit's column comes immediately by multiplication; the 4 of the ten's columns by adding 2 plus 2. The 6 is the result of 2 times 2 plus 1 plus 1. The rest comes from symmetry. The product of 131 by 131 equals 17,161 is just as symmetrical, but the symmetry is hidden because 1 has been added to the 6 in the fourth place. Written $16161+1000=17161$ the symmetry is plain. All such numbers as 141, 151, 161, 191 may be squared in this fashion. This is a particular application of a much more general method of multiplication which might be called the algebraic method.

Just as

$$(ax+b)(cx+d) = acx^2+(bc+ad)x+bd,$$

so, 73×72 may be written:

$(7t+3u)(7t+2u)$ equals:

6	.....	u
35	.....	t
49	.....	h
5256		

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The addition may be performed mentally and the result written down at once. The position of the digit tells whether it is units, tens, hundreds, etc., so the multiplication may be carried on without the use of t or u. (With practice, this too becomes a mental operation.)

Thus: 211×328:

Units	1×8	$= 8$
Tens	$(2 \times 1) + (1 \times 8)$	$= 10$
Hundreds	$(2 \times 8) + (3 \times 1) + (2 \times 1)$	$= 21$
Thousands	$(2 \times 2) + (3 \times 1)$	$= 7$
Ten thousands	3×2	$= 6$
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A COMPARATIVE STUDY OF CONGRUENT AND SIMILAR TRIANGLES.

By Robt. R. Goff,

B. M. C. Durfee High School, Fall River, Mass.

	A. Congruent Triangles.	B. Similar Triangles.
1.	Scalene triangles: angle, angle, side.	angle, angle.
2.	Scalene triangles: side, angle, side.	side, angle, side.
3.	Right triangles: side, acute angle.	acute angle.
4.	Right triangles: two arms.	two arms.
5.	Right triangles: arm, hypotenuse.	arm, hypotenuse.
6.	Scalene triangles: side, side, side.	side, side, side.
7.	The general case for all right triangles is: side, side or side, acute angle.	side, side or acute angle.
8.	Summary: The four methods of proving triangles congruent, covering all cases, are 1, 2, 6, and 7.	Summary: The four methods of proving triangles similar, covering all cases, are 1, 2, 6, and 7.

It will be noticed that: Where there are equal angles in congruent triangles, there are equal angles in similar triangles; where there are equal sides in congruent triangles, there are sides in proportion in similar triangles, except when only one pair of sides are equal in congruent triangles, and then there is no proportion in similar triangles.

The basic theorems in each group are 1 and 2 (although 2 can be made to depend upon 1, and in that case, only one is basic). These are proved by superposition. The other theorems in each group are proved by getting the conditions of one of the basic theorems, 1 or 2.

The method of proof for 3 in each group is 1.

The method of proof for 4 in each group is 2.

The method of proof for 5 in each group is adjacent position and 1, and in the proof of B, A is used.

The method of proof for 6 in each group is adjacent position and 1 (although the method of 6A can be 2); and in the proof of B, A is used.

The summary in each group consists of 1, 2, 6, and 7.

The principal use of congruent triangles is to prove lines or angles equal.

The principal use of similar triangles is to prove lines in proportion or angles equal.

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THE CHEMISTRY TEACHER'S OPPORTUNITY.

By FRANK B. WADE,
Shortridge High School, Indianapolis.

My title might well have been "The Science Teacher's Opportunity" and it is only because I have perhaps considered more specifically the connection between the conditions brought about by the great war and the teaching of chemistry that I have taken the above as my title. You will all doubtless speedily apply to your own fields such general suggestions as I may be able to bring to you and the specific illustrations that I may select from chemical material will, I hope, serve to point the way to concrete application of these general principles.

In the present public emergency, the welfare of the country depends more than at any time in our past history upon the successful application of the principles of science to the solving of the problems thrust upon us by the war. It thus comes about that there falls upon the teachers of science a tremendous duty and a great opportunity.

As the public begins to realize and to appreciate more and more how dependent our modern civilization is upon the proper application of scientific knowledge, especially in time of war, there will come to us a larger and larger demand for efficient instruction in scientific subjects. We will be expected to give a proper start to the scientists of the future. With this demand, however, we may expect to find a certain lack of understanding of the length of time required to produce a real chemist or other scientist, and it will be one of our new duties to stand tactfully, but firmly, against any attempt to have us teach applications of chemical or other scientific principles before we have had time to teach the principles themselves.

We secondary school teachers will have all we can do to properly start our young scientists in the elementary principles of our sciences. If we can lay sure foundations, the colleges and technical schools will attend to the further progress of the student. Some of us have perhaps devoted rather too much time in the past to what we thought were practical applications, and too little time to the real solid foundations; and in consequence it is undeniable that many college teachers would rather themselves start students in the special sciences than have us do it for them.

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We must correct this condition by giving our pupils thorough drill in all the fundamentals of our subjects and by training them to think chemically or physically, as the case may be; and then these college men will gladly accept the help we can give them in getting science students rightly started. We have more time than the college teacher and a better chance to get at the individual pupil and if we go about our task intelligently, we should be better able than the college man to teach the beginnings of the science courses.

The early recognition of the pupil who is adapted to follow a scientific career and the encouragement of that type of pupil to elect further science courses will be, to a greater extent than ever before, one of our duties and privileges.

Up to this point in my discussion I have spoken as though the preparation of pupils for actual scientific work were the all important matter in secondary science teaching. Really, however, while we will probably be called upon to start more pupils than formerly in scientific careers, the actual numbers so started by any of us will still be very small when compared to the numbers of pupils who will take our science courses with other ends in view. All men cannot be scientists. While this would be a pretty poor world were it without any scientists and a rather better one if we had a few more of them who could get what we now know into general use, yet I suspect that too many scientists might prove almost as bad as too few.

It will thus be necessary for us to provide suitable instruction for the ninety per cent or so of our pupils who will probably never become scientific men. Our principal business in life ought to be to find out just what we can and ought to give these pupils in the present crisis in order to best fit them to cope with the many problems that are upon us as men and women rather than as scientists.

The crying need of the times is clearly brought out by a recent letter from President Wilson's pen. The letter was addressed to "School Officers." It reads as follows:

> The war is bringing to the minds of our people a new appreciation of the problems of national life, and a deeper understanding of the meaning and aims of democracy. Matters which heretofore have seemed commonplace and trivial are seen in a truer light. The urgent demand for the production and proper distribution of food and other national resources has made us aware of the close dependence of individual on individual and nation on nation. The effort to keep up social and industrial organizations in spite of the withdrawal of men for the army has revealed the extent to which modern life has become complex and specialized.

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These and other lessons of the war must be learned quickly if we are intelligently and successfully to defend our institutions. When the war is over we must apply the wisdom which we have acquired in purging and ennobling the life of the world.

In these vital tasks of acquiring a broader view of human possibilities the common school must have a large part. I urge that teachers and other school officers increase materially the time and attention devoted to instruction bearing directly on the problems of community and national life.

Such a plea is in no way foreign to the spirit of American public education or of existing practices. Nor is it a plea for a temporary enlargement of the school program appropriate merely to the period of the war. It is a plea for a realization in public education of the new emphasis which the war has given to the ideals of democracy and to the broader conceptions of national life.

In order that there may be definite material at hand with which the schools may at once expand their teaching I have asked Mr. Hoover and Commissioner Claxton to organize the proper agencies for the preparation and distribution of suitable lessons for the elementary grades and for the high school classes.

Lessons thus suggested will serve the double purpose of illustrating in a concrete way what can be undertaken in the schools and of stimulating teachers in all parts of the country to formulate new and appropriate materials drawn directly from the communities in which they live.

WOODROW WILSON.

It is the need for the formulation of such new and appropriate materials drawn from the subject matter of chemistry that chiefly interests me at this time. This material must have a bearing on current problems of individual, of community and of national life. We must first teach the underlying principles to the mass of the class as well as to those who are to become scientists; then we must hunt out and bring before them the relations of these principles to current problems. In so far as it is possible, our illustrations and our experiments should be derived from or applied to such problems. We should also bring to our classes information as to what has been done and is being done by practical scientists toward solving the real problems of the country and of the people.

If we can thus make our pupils intelligent as to the need for and the uses of science, we shall be doing them a real service of a very practical nature, far more practical indeed than any service we can render them in the way of so-called practical applications of half-learned principles.

Having now stated my thesis, may I not take a few more minutes of your time to suggest in concrete fashion how a chemistry teacher can act upon my suggestions in a few specific instances.

Let us consider the problem of fuel conservation. While our fuel administration battles as best it can with the problems of supply and demand, and of transportation, what can we chemistry teachers do toward helping our pupils and their

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parents and our communities to a real saving of fuel? Can we not, at about this time in our courses, having made clear to our students the principles underlying ordinary combustion, show them by experiment and by visits to manufacturing plants that the escape of smoke can and should be largely prevented, especially in large establishments? Can we not show them that destructive distillation is bound to follow the heating of soft coal—that it does not follow the heating of coke or charcoal or anthracite coal; that the first two of these last three fuels have certainly, and that the last has probably already undergone destructive distillation and cannot repeat, and hence that they are not smoke producing? Can we not take our pupils to the gas works where "smoke production," if we may call it that, is the principal source of revenue, and show them how the smoky products are condensed and separated to be sold? They can then profitably visit a modern boiler plant having automatic stokers to regulate the rate of feed of the fuel and hence to limit the destructive distillation, so that relatively small quantities of volatile products are produced per minute. The Dutch ovens or other means for superheating the smoky products, so that they will be sure to be kindled and kept above their kindling points until combustion is complete, will next be shown and the method in use at the particular plant for supplying adequate quantities of fresh air to the fuel will be pointed out. By opening the furnaces at the proper point, the class can be shown that the products of combustion are colorless and transparent, indicating complete burning of the valuable fuel supplied to the furnaces.

Such a trip can be followed by some discussion as to ways and means of at least reducing the amount of smoke from domestic heating devices, although it must be confessed that here we encounter an unsolved problem for our future scientists to cope with. If all our pupils, and through them their parents, hear of what can be and even now is being done in the way of successful smoke prevention, and especially if we succeed in impressing upon them not only the enormous waste involved in the loss of volatile fuel material but also the very great direct financial gain that should and can result from the installation of proper devices for prevention, we shall have done a very practical and serviceable thing.

If, in addition, a little newspaper publicity is obtained for this sort of work, an even larger usefulness may result. Most

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papers would welcome a well written article from the teacher, in which the need of the country for fuel conservation was briefly alluded to and a modest claim made for the great saving that proper combustion might make. This could then be followed by a section in which the conditions necessary for proper combustion were set forth in simple language, and then one or two of the most successful types of smoke prevention devices could be briefly described and pictured by means of simple diagrams. Such an article would find a welcome in many a Sunday edition of even the large city papers.

There are many other topics treated in general chemistry which could be similarly connected with the needs of the country. I shall mention but one more and that is the conservation of food by preserving, drying, canning, smoking, salting, and the use of a chemical preservative, or by refrigeration. At the time that decay is studied, perhaps in connection with oxidation and combustion, we have a fine opportunity to show why each of the above methods is effective and it may even be worth while, if the season permits, to segregate the girls for a few days and to give actual instruction in home canning. We have a steam cooker in my own department, and gave the girls a short but thorough course last spring in the principles and practice of canning. Up-to-date methods were taught and some fine canned goods were produced under the instruction of Miss Garber, of my department.

The second part of my thesis, and the final part for the present, deals with the bringing before our pupils of information as to the big things that have been done by American chemists since the war began. You will at once think of the progress that has been made in the production of synthetic dyes and of the more than $170,000,000 that has been invested in the American dye industry. Another big thing, also, that is being done, and one that can perhaps be better explained to elementary pupils, is the extensive fixation of atmospheric nitrogen, that has been undertaken by the Federal Government. At the time you are studying the atmosphere, and have called attention to the seeming inactivity of its nitrogen, you can bring in some account of this great chemical industry that is of such vital importance in war times and scarcely less important in times of peace.

I will not take your time to review recent progress in methods of nitrogen fixation, but rather refer those of you who may

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wish to prepare material for class use to the excellent synopsis of the several practical methods given by Chas. L. Parsons of the Department of Chemistry of the Bureau of Mines in the *Journal of Industrial and Engineering Chemistry*, the September number, 1917.

Mr. Parsons visited Europe to study the question for the U. S. Government and he gives a splendid account of the various processes, with discussion of the advantages and disadvantages of each, and concludes by making recommendations as to the use of the $20,000,000 appropriation authorized by Congress for the fixation of nitrogen.

Or see "Fixation of Atmospheric Nitrogen" by Joseph Knox, D. Van Nostrand Co., 1914.

To sum up my suggestions briefly—let us as science teachers prepare to give thorough training in the fundamental principles of our sciences to a rather larger number than usual of candidates for a scientific career. Let us, however, at the same time draw our illustration from, and apply our principles as far as is possible to, current scientific work with a special view to helping in a small way to solve some of the vexing problems forced upon us by the war and to instruct our pupils as to what is being done for them and for us all by applied science.

It is only thus that we can answer successfully to the call of the hour and "do our bit" toward meeting the needs of our communities and of our country.

WIRELESS TIME SERVICE IN THE PHILIPPINE ISLANDS.

The progress in the time service of the Philippine Islands is made evident from the fact that since October 1, 1917, the Cavite Radio Station, cooperating with the Bureau of Posts and the Manila Observatory, sends out time signals of the 120th meridian east of Greenwich at 11 a. m. and 10 p. m. every day, Sundays and holidays inclusive. Manila holds an enviable portion in the Pacific and the interests of shipping companies making Manila a port of call are too important to be overlooked. Accurate time signals and wise typhoon warnings are of immense value to the units of the United States Asiatic fleet, to army transports and in general to oversea shipping.

For the purpose of sending time signals, the transmitting clock of the Manila Observatory is connected with the Cavite Wireless Station through the Bureau of Posts. Manila Observatory time signals begin at 10:55 a. m. and 9:55 p. m. standard time of the 120th meridian east of Greenwich, and continue for five minutes. During this interval every tick of the clock is transmitted, except the 28th, 29th, 54th, 55th, 56th, 57th, 58th and 59th of each minute. Experiments made on board the U. S. Wilmington, Monterey, Sheridan, Merrit and the commercial steamer Colombia of the Pacific Mail gave satisfactory results.—M. Selga in *Popular Astronomy*.

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VALID AIMS AND PURPOSES FOR THE STUDY OF MATHEMATICS IN SECONDARY SCHOOLS.

By ALFRED DAVIS,
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Williamsburg, Va.
Chairman of a Committee of the Mathematics Club of Chicago Appointed to Investigate This Topic.

(Continued from March number)

PART III.

If we are to realize our aims and purposes in the teaching of mathematics it may be necessary, as times and conditions change, to vary both subject matter and methods of teaching it. However, such change is evidence of life, not of death.

The New England Report, already referred to, says, "Some teachers of mathematics in the high schools are inadequately prepared for their work, perhaps teaching it only incidentally. Conditions in normal and grammer schools are probably worse." Matthew Arnold says, "The plan of employing teachers whose attainments do not rise far above the level of the attainments of their scholars has been tried and it has failed." By far too much emphasis is put on methods in schools of education for prospective teachers when these would-be teachers have not thoroughly mastered the subjects they seek to teach. Not that any teacher can know too well how to teach, but the study *about* education should never be at the expense of education itself. The scholarship requirements for teachers should be higher than they are; indeed, we can scarcely make them too high; for superior scholarship in the subject one is to teach is of supreme importance, and all of us would be happier with greater efficiency in our chosen field. Much of the criticism of mathematics today is from those who are perfectly well informed as to how it ought to be taught, but they have little knowledge—and less appreciation—of the subject. Prof. L. T. More (*Nation*, May 3, 1917) says, "A few months in a schoolroom acting as an assistant to an experienced teacher after a sound college course will prepare a person for teaching more effectively than pedagogical courses." The plan is worth thinking about.

On the other hand, granting adequate scholarship, all who enter the teaching profession need technical training in teaching, more than most of them get at present. Knowledge of a subject does not necessarily imply ability to teach it; it is frequently assumed that it does, but some brilliant students have made

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very poor teachers. It is a crime to make the classroom a laboratory in which the would-be teacher shall try by hit-and-miss efforts to gain experience. Doctors of medicine do not gain all their preparation by experimenting on the helpless sick. Lawyers are not entrusted with our reputations before they have earned to practice law. The teacher in training should be under the direction of an expert. Our material, the plastic minds of boys and girls, is too valuable to be trifled with. Besides, we have too much at stake in the reputation of our subject to take such chances. The teacher must learn to see the subject from the pupil's angle and to present it effectively; to accomplish this he must, while practicing under an expert, master the fundamentals of psychology and of pedagogy. Above all, the teacher's preparation should draw out his individuality, the thing that makes him different from every other teacher; and it should enable him to avoid the ruts from the beginning.

Much of the inability of students to master mathematics is due to poor teaching at some point in their career. Those who cannot master a reasonable amount of mathematics are probably no more numerous than physical defectives. Someone has said that algebra is "fool proof," and this has been assumed true by many principals in assigning work to teachers. Dr. Snedden, ("Problems of Secondary Education," p. 225) says, "Algebra is one of the easiest of secondary school subjects to teach with a certain degree of apparent effectiveness. Lessons and hard tasks can be assigned easily, and a very duffer of a teacher can make pupils work slavishly on this subject. In most small high schools today it will be found that the teacher with least special preparation for his work is usually teaching algebra. The case here is somewhat analogous to the practice of 'electric' and 'magnetic' healing by 'near' physicians." This is a somewhat frank statement that the trouble with secondary mathematics is not with the subject but with the teaching of it. Poor teaching gives a subject the reputation of being difficult. When pupils pass the word along that algebra or geometry is hard and uninteresting the battle is lost before it is begun. Even a good teacher will have difficulty in overcoming this prejudice.

Another source of trouble is the assumption that when a pupil masters a principle this guarantees his ability to use it. Such is not the case. Many of our best students appear sadly inefficient when they leave high school. Application is quite

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as important a part of our work as the teaching of principles. Of what value is a tool unless we are taught the actual use of it? Prof. Judd ("The Psychology of High School Subjects," p. 130) says, "It is contrary to experience to assume that students can apply mathematics to the other sciences or to the practical affairs of life unless they are trained to see mathematical relations in other forms than those in which they are commonly presented in the schools. The student who knows the abstract demonstrations of geometry, but does not realize that knowledge of space is involved in every manufacturing operation, in every adjustment of agriculture and practical mechanics, is only half trained. Application must be a phase, and an explicit phase, of school work. Application is as different from pure science as pure sciences are different from each other."

In addition to the inefficiency of teachers we have the inefficiency of students as such. This is probably due to two causes. First, the idea is somewhat prevalent in the elementary schools that a pupil may gain an education by being amused. He is not trained to feel nor to know personal responsibility. His education is entirely a matter for the teacher to look after. He even resents any attempt to secure his initiative if the effort he is to make savors of drudgery or requires hard thinking. School work must be a pleasure and without responsibility. Second, there is a tendency on the part of college students to ignore study. This spirit finds its way into the high school, which so often tries to imitate the college. Consequently, many who could be good students fail; mathematics, requiring the sort of effort they know nothing about, is impossible with them. Ability in mathematics may, usually, be considered synonymous with ability to be a good student. Prof. Schultze ("Teaching of Mathematics in Secondary Schools," p. 25) says, "It is a common experience to see a pupil in the upper grades suddenly wake up to the meaning of mathematics and thereby change his attitude towards study in general." A good standing in high school is almost certain to guarantee a good college record and a successful life. This matter has been splendidly treated by Wm. T. Foster, President of Reed College, Portland, Oregon, in "Should Students Study" (*Harper's Monthly*, September, 1916). He raises the question, "Are good students in high school more likely than others to become good students in college?" Three colleges in as many states are considered. Of hundreds of students in the University of Wisconsin, above

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80 per cent of those in the first quarter in the high school remained in the upper half of their classes throughout the four years of their university course, and above 80 per cent of those who were in the lowest quarter in high school did not rise above mediocre scholarship in the university. Only one in five hundred of those in the lowest quarter reached highest rank in the university. The University of Chicago found that students that failed to receive in high school an average higher than pass by at least one-fourth of the difference between the passing mark and 100 per cent failed in college; such students are, therefore, not admitted; where exceptions are made the record in college is seldom satisfactory. Reed College, at its fall opening five years ago, admitted only those students who ranked in the first third in the preparatory schools: about 20 per cent were exceptions to this rule and 2 per cent were below the median line; these exceptions were selected as the best below the first third. Of these exceptions, practically none rose above the lowest quarter in their college classes. The same results are shown to be true of those who go from college to the professional schools. Surely "promise in high school becomes performance in college," and the mediocre in high school are out of the race. President Foster says, "If all these studies prove anything, they prove that there is a long chain of causal connections binding together the achievements of a man's life and explaining the success of a given moment. . . . Luck is about as likely to strike a man as lightning and about as likely to do him any good. The best luck a young man can have is the firm conviction that there is no such thing as luck and that he will gain in life just about what he deserves and nor more. . . . At a convention of teachers not long ago a speaker ridiculed a German boy who, upon failing in a recitation, put his head upon his desk and cried. He said he had never seen such a boy in the schools of this country. . . . Nothing seems to promise failure in the tasks of tomorrow with greater certainty than failure in the studies of today. . . . Among teachers the greatest number of criminals are not those who kill their young charges with overwork, but those who allow them to form the habit of being satisfied with less than the very best there is in them."

From a study by President Lowell, of Harvard (*Educational Review*, October, 1911), it appears that President Foster's conclusions apply to Harvard students. Of 609 who graduated

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from college with A. B. plain, only 6.6 per cent obtained cum laudi in Law School. Students of mathematics attained highest honors in Law School. Students of classics stood next. The qualities of diligence, perseverance, and intensity of application acquired in the study of mathematics secured a higher degree of success than was obtained by others. The pupil should be impressed with the importance of proper habits of study and he should be aided in forming these habits. If he finds the work very hard, let him profit by the determination of Robert Bruce as he watched the spider, after many futile efforts, finally reach the ceiling. If he is inclined to waste time let him get inspiration from the words of Hotspur before the battle of Shrewsbury:

> "Oh, gentlemen, the time of life is short;
> To spend that shortness basely were too long,
> If life did ride upon a dial's point,
> Still ending at the arrival on an hour."

The New England Report says, "There is real danger that depreciation of mathematics by persons supposed to be experts in matters of secondary education may, unless vigorously met, exert an unfavorable and undue influence on public opinion." It would seem desirable that teachers of mathematics assert their claims more energetically, for it is not always safe to assume that right will win without an advocate. It is not necessary to enumerate these criticisms; we are all familiar with them. Some have been justified and have already resulted in improved courses and methods in the better high schools; for no subject is so perfect as to need no improvement; and any subject will soon be out of date if it lacks the elasticity which enables it to fit new conditions. There is still room for much improvement. Dr. D. E. Smith says, "I think unquestionably there has been too high a pace set in the matter of abstract drudgery. I think there is no question but that we must harmonize and vitalize our algebra." Other criticisms have been answered time and time again, but like Banquo's ghost they will not down. Prof. R. D. Carmichael, in *Science*, May 18, 1917, says, "It seems that no body of thought has been of more importance in human progress and at the same time been criticized more freely than the science of mathematics. Much of this criticism seems to be good natured and to amount to little more than a quasi-humorous way of expressing the critic's unashamed ignorance. At first sight one might treat this as harmless; but from the

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point of view of general interest it can hardly be passed over in such a way. How this ignorance is to be overcome I cannot say. Perhaps one of the first requisites is to find some means of overcoming the shamelessness with which individuals otherwise well trained contemplate their own ignorance of mathematics." Prof. Chas. N. Moore, University of Cincinnati, in *The American Mathematical Monthly*, February, 1916, says, "The movement against mathematics is, for the most part, confined to a group of theorists who feel that they must advocate something new in order to convince their readers that they are investigators. This group, however, has made up in volume of sound what it has lacked in numbers. . . . The statement that there is at the present time much uncertainty as to the educational value of algebra and geometry will not bear examination." Dr. D. E. Smith, in *T. C. Record*, May, 1917, says, "It is by no means the advanced educator who denies a disciplinary value to geometry; it is rather, I think, either the educator who is slipping behind in the race, or the one who has never been in the race at all. If you do not think so, ask a man like Professor Thorndike. If anyone says to me that we have statistics to show that young people spend a year on a subject whose chief purpose is the logical proving of statements and are not thereby made more logical in their other lines of mental activity, now or in years to come, then I tell him frankly that not only do I not believe it but that scientific men generally do not." Our critics seem to be so fascinated by the weight and worth of their own ideas that no reply can reach them. Some seek to surprise us with the resurrection of issues that have been dead for ages. Others, in the face of irrefutable argument, do the seemingly impossible; they absolutely ignore the other side of the issue; they continue their argument as though it were impossible for them to be mistaken or for anyone to make a reply worthy of notice. Prof. Paul Shorey, in "The Assault on Humanism" (*The Alantic Monthly*, June, 1917), says, "They either have not read the literature which they controvert, or they intentionally ignore it. They do not inform their readers of its existence, and they do not even tacitly amend their own arguments to meet its specific contentions. In controversy, this is what Lincoln called 'bushwhacking.' In the authors of the textbooks of the science or the history of education it is the abandonment of the scientific for the frankly partisan attitude. . . . They not only argue as partisans against the classics but they systematical-

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ly suppress both the arguments and the bibliography of the case for the classics. . . . The principal effort of the classicist who aims at argument rather than eloquence must be to shame his opponents from their unfair tactics, their neglect of the evidence, their preposterous logic, and to urge the educated public to examine the matter for themselves. He must wearily repeat his old list of 'must nots' and 'don'ts.'" These statements apply with equal force to many of the critics of mathematics.

As teachers of mathematics, we are too often the victims of men officially higher up, who know little of mathematics or of its teaching, and whom we allow to do our talking and planning for us. Why should courses and curricula in mathematics be arranged and criticized by principals and superintendents who have no appreciation of the subject? It seems to be different in Europe. Prof. J. C. Brown, in a recent bulletin of the U. S. Bureau of Education, says, "European school men believe that a course in mathematics should be planned by those who know mathematics rather than by educators who are practically ignorant of the subject." Educators not familiar with mathematics may aid in an advisory way; but, if the subject does what we claim for the student, it must have done that in some measure for the teacher; who then can be so well fitted to mould the subject into better form or to adjust its courses?

Some of the difficulties, and lack in interest of students in the study of algebra and geometry, are the result of preconceived notions, the echoes of what educational theorists have said. We have heard a teacher say that it is a pity that the active productive minds of young people should be burdened with so formal a study as algebra. A student who is looking for an easy time and who finds algebra hard work thinks he has sufficient authority in such a statement for loafing on the subject. This point is cleverly made by Prof. Crathorne in a parable given in "Algebra from the Utilitarian Standpoint" (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, pp. 418-431). After considerable discussion on the part of Dr. Highbrow, Dr. Practical Man, Dr. Brown, and an Average Parent regarding difficulties in algebra and dislike for the subject, which the Average High School Pupil seemed to be experiencing, the pupil broke in with, "But I don't dislike algebra. I never did; but so many people argued that I disliked it that I began to think there was something wrong with it." That much of the lack of interest on the part of students towards mathematics is merely assumed is shown

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in a report by this club published in SCHOOL SCIENCE AND MATHEMATICS, October, 1916. A test was given in three high schools—University High and Hyde Park, Chicago, and Oak Park, Ill.—to determine from the statements of students in these schools the measure of enjoyment they found in their various studies. Out of a total of 2,018 pupils reported as taking mathematics, 1,769, or 87.7 per cent, said they got some enjoyment from the study; 991, or 49.1 per cent, claimed to get very much enjoyment; and only 229, or 12.3 per cent, said they got no enjoyment. With one year of mathematics (at least) required of all students in these schools, and in view of present criticisms, these results are remarkable. Subjects which ranked higher were purely elective. It is the opinion of Prof. J. W. Johnson that 49 per cent of the pupils who study mathematics, including the high schools of the entire country, would vote that they got very much enjoyment from the study of mathematics.

It would be a mistake to try to persuade ourselves that no criticisms are worth our attention. The destructive critic always defeats his own ends, and is unworthy of serious consideration; but the constructive critic is always welcome; providing he maintains a friendly spirit. We must have the assistance of the latter. G. St. L. Carson, in "Mathematical Education," pp. 61 and 85, says, "The whole world is going through a transformation, due in part to scientific and mechanical invention and in part to the growth of separate nations, each with its own methods and ideals, of which no man can see the outcome. Our function, the function of all teachers, is to produce men and women competent to appreciate these changes and to take their part in guiding them so far as may be possible. Mathematical thought is one fundamental equipment for this purpose, but mathematical teaching has not hitherto been devoted to it because the need has but recently arisen. But now that it has arisen and is appreciated, we must meet it or sink, and sink deservedly. Neither the arid formalism of older days nor the workshop reckoning introduced of late will save us. The only hope lies in grasping that inner spirit of mathematics which has in recent years simplified and coordinated the whole structure of mathematical thought, and in relating this spirit to the complex entities and laws of modern civilization. . . . Salvation from our present difficulties can come only from the efforts and experiments of teachers themselves. Educational matters are in a ferment. Men are asking more and more insistently

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why this and that are done, and they are right in their insistence. Unless fitting answers are ready, our work will stand condemned; the degradation of our subject to the domain of purely immediate utility will surely follow, as also the loss of that higher mental training which is so essential to the formation of an efficient citizen." To meet this situation we would make the following suggestion:

Mathematics should be *required* of every secondary school pupil. This required work may consist of courses alloted to the junior high school, if that institution is to prevail; or it may, under the present arrangement, be reduced to one year and consist of algebra and geometry, with some reference to the use of the trigonometric functions. The purpose being, in any case, to give to all, early in their course, some command of mathematics as a tool; to give some knowledge of its historical development; to instill an appreciation of the importance, possibilities, and beauties of the subject; and, above all, to give the pupil a chance to find himself. Those who have little aptitude for mathematics would not elect additional courses, and yet would realize some of the benefits from its study. This would probably reduce pupil mortality in our high schools and remove much of the grounds for present criticism. On the other hand, such an arrangement would throw responsibility on the teacher to interest his pupils in mathematics while taking the required courses so that they would elect other courses in the subject. This might aid in securing better teaching and better teachers. This club has already expressed its approval of reducing the required mathematics in high school to one year. Prof. Paul H. Hanus, of Harvard, in his book, "A Modern School," pp. 76 and 83, says, "Permanent lack of interest in a given field of work is an indication of corresponding incapacity; for growing interest and capacity always go together. . . . No pupil should be required to pursue a study after it is clear that it does not appeal to him. Under most circumstances one year is enough—and it is not too much—to ascertain whether a study does, or does not, challenge a youth's interest and capacity. . . . One year of elementary algebra and geometry may open the pupil's mind to one of the most useful, the most profound, and to some minds most fascinating systems of thought which man has developed—a result which can never be expected to follow from what the pupil has learned in the narrow field covered by arithmetic." Regarding the nature of elementary courses in mathe-

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matics, Prof. G. A. Miller, in the preface to his "Historical Introduction to Mathematics" (1916), says, "Early mathematical courses should be more informational, especially along historical lines, on the ground that knowledge begets interest in knowledge." That a well-planned and interesting course should be required there can be no question. No one can know whether or not he has aptitude for the subject until he knows something about it. One cannot know anything about mathematics, to such an end, until one has studied the subject.

The Lincoln School, established this fall as a part of Teachers College, is an effort to determine the value of some of the modern theories of education, and to work out a better program of study than we have at present. We shall await with interest and shall welcome the results of this effort. It announces that it will attempt "in the subject of mathematics to develop a course which connects the study of mathematics with its use, adequate provision being made for those whose special abilities or future interests relate to mathematics. And in all subjects, whenever feasible, effort will be made to base schoolwork upon real situations, to the end that schoolwork may not only seem real to the pupil, but be so." It would seem that our work in algebra and geometry might be more completely related to the interests and activities of the pupil than at present. It would seem that this result might be accomplished by a greater number and variety of practical problems, even though these had little direct relation to the utility of the subject in later life. To say that only those problems which are directly related to the doing of the world's work are legitimate is to place mathematics on a utilitarian basis, and this we have shown to be wrong. The values we have suggested can be realized when the pupil is thoroughly interested in his work regardless of its actual use in later life. However, as often as possible problems should be useful as well as interesting. Considerable progress is being made in this line in various parts of the country.

Surely all important departures from the established order of things should be made slowly, and only after these have been carefully tested. Experiments with high school mathematics should be made in schools adapted to that use, and by those who are expert in mathematics as well as in the teaching of the subject. This, of course, would not preclude the possibility of important discoveries and contributions by any teacher situated in any school.

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The high school is *not* the place to specialize. The required courses in mathematics must be adapted at the same time to the pupil who does not and to the one who does go to college. Diversified courses may have a place as electives and in vocational and technical schools. Only a very small number of high school pupils can have any adequate notion of what their life's work should be. It is a great mistake to force—or even to permit—them to follow courses that may exclude them from the vocation for which they are best fitted. President Hadley, of Yale, says that only about 8 per cent of pupils previous to seventeen years indicate inclinations towards any vocation. Dr. Joseph Rausohoff, an eminent surgeon of Cincinnati says, (*School and Society*, June 19, 1915) "Up to the fifteenth or sixteenth year the average boy who goes to a high school can have no idea as to the work he expects to follow in later life. A general course will give the boy a general knowledge which will later permit him to develop along certain lines, as his bent or necessity may indicate. Such a course makes the possibility, at least, of a general culture which will permit him to indulge in one or another intellectual hobby later in life. I would above all things not exclude mathematics, but make it compulsory in every high school curriculum, because it is, after all, the only study which will inculcate into the young mind that absolute precision is among the human possibilities." Opportunity for the broadest possible education must be given to everyone. This is an essential thing in a democracy where equal opportunity should be enjoyed by all. We cannot say to one pupil, "The door to the highest attainments in education is open to you"; and even suggest to another, by limiting his field, that the same door is practically closed to him. This should be our ideal in curriculum making and in teaching, and it should be kept constantly before both teacher and student. The way to the highest achievement must not be closed to anyone.

We have quoted freely in defense of our arguments, for the words of a thinker carry their own weight. We are reminded of the words of Emerson, in "Letters and Social Aims, Quotation and Originality": "A great man quotes bravely, and will not draw on his invention when his memory serves him with a word as good." The value of a well-expressed thought or of a good piece of work depends on the use made of it—the passing of it along. We have quoted from specialists in mathematics, for who but those who know and appreciate a subject can speak

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with authority about it. Lest this should seem a biased attitude, we have also quoted specialists in other lines, and have even given the opinion of students in high school. Some may object that mathematics has changed since some of these statements were made concerning it, and that they are therefore of doubtful value. While mathematics is not today what it was yesterday, it is not less but more important.

That mathematics is advancing today as never before is shown by the following quotations:

G. A. Miller, "Historical Introduction to Mathematical Literature," p. 22, "It would be very conservative to state that the first decade and a half of the present century (twentieth) produced at least one-fifth as much (mathematical literature) as all the preceding centuries combined. Hence it appears likely that the twentieth will produce, as the nineteenth century has done, much more new mathematical literature than the total existing mathematical literature at the beginning."

C. J. Keyser, in a lecture ten years ago, "2,000 books and memoirs drop from the mathematical press of the world in a single year, the estimated number amounting to 50,000 in the last generation. . . .

"Indeed, the modern developments of mathematics constitutes not only one of the most impressive, but one of the most characteristic, phenomena of our age. It is a phenomenon, however, of which the boasted intelligence of 'universalized' daily press seems strangely unaware; and there is no other great human interest, whether of science or of art, regarding which the mind of the educated public is permitted to hold so many fallacious opinions and inferior estimates. The golden age of mathematics—that was not the age of Euclid, it is ours."

President N. M. Butler, of Columbia University, "Modern mathematics, that most astonishing of intellectual creation, has projected the mind's eye through infinite time and the mind's hand into boundless space."

Jas. Pierpont, "Surely this is the golden age of mathematics."

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A PRACTICAL VALENCE EXPERIMENT.

By PAUL H. FALL,

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Doubtless many teachers of chemistry use, as a class demonstration, Dr. W. A. Noyes' famous valence experiment as given in his "Textbook of Chemistry." Perhaps it is not given in manuals as a laboratory experiment for the student to perform because of the difficulty of handling the sodium. It occurred to the writer to weigh the sodium in a small gelatin capsule. This method may not be new but the writer has seen no mention of it in any journal or manual.

The experiment as carried out in our laboratory is as follows: Lengths of clean (made so by rubbing with emery paper) magnesium ribbon and aluminum wire are cut which will give approximately milligram-atomic weights of the metals. (This is easily determined by weighing 10 cm. of the ribbon or wire and then by proportion finding what length is required to give 24.3 mg. of magnesium or 27 mg. of aluminum.) Each student takes a small envelope containing the empty capsule he has weighed to the stock room where the attendant puts in approximately a milligram-atomic weight (23 mg.) of sodium from a small sodium press, to be described later. The capsule of sodium should be weighed soon after filling; otherwise the surface of the sodium will oxidize. In most cases, however, the oxidation in one hour is negligible.

After all three of the metals have been weighed they are introduced under three inverted test tubes of about six normal hydrochloric acid. For the sodium, water alone is sufficient. The capsule of sodium rises to the bottom of the inverted test tube and in a few minutes enough of the capsule dissolves to allow the sodium and acid or water to react. (As an explosion sometimes occurs with sodium, it is best to throw a towel over the tube.) Any sodium retained by the capsule may be made to react with the water by shaking the test tube in a deep pneumatic tank of water. By means of rubber bands the height of water or acid left in each tube is marked, and then the volume of hydrogen generated in each case is measured.

In each case, from the volume of hydrogen obtained (when reduced to standard conditions) and the weight of the metal used, the student computes what volume of hydrogen he would have obtained had he used exactly a milligram-atomic weight of the metal. Then the actual weight of this hydrogen is de-

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termined and the ratios in which it is displaced by the metals is computed.

It will be found in exact work that 23 mg. of sodium will displace 11 cc. (1 mg.—which is the milligram-atomic weight) of hydrogen; 24.3 mg. of magnesium will displace 22 cc. (2 mg.) of hydrogen; and 27 mg. of aluminum will displace 33 cc. (3 mg.) of hydrogen. It should be remembered that just one milligram-atomic weight of the metal was used in each case. By using the atomic weight of each metal in milligrams, it is evident we should be using an equal number of atoms of each metal. Hence from the above results it is evident that:

1 atom (or atomic weight) of Na will displace 1 atom (or atomic weight) of H, and as a result will hold 1 atom (or atomic weight) of Cl.

1 atom (or atomic weight) of Mg will displace 2 atoms (or atomic weights) of H, and as a result will hold 2 atoms (or atomic weights) of Cl.

1 atom (or atomic weight) of Al will displace 3 atoms (or atomic weights) of H, and as a result will hold 3 atoms (or atomic weights) of Cl.

We see that the displacing capacity (towards H) and the holding capacity (towards Cl) is twice as great with Mg as with Na and three times as great with Al. We call this capacity *valence* and define as univalent, any element one atom of which displaces one atom of hydrogen or holds one atom of chlorine; as bivalent, any element one atom of which displaces two atoms of hydrogen or holds two atoms of chlorine; and as trivalent, any element one atom of which displaces three atoms of hydrogen or holds three atoms of chlorine.

During the past two years this experiment has been performed by more than 350 students in our laboratory in the beginning course and with very good quantitative results and, best of all, it has proved a great aid to the understanding of valence by the student. In the Analytical Department students have been using the gelatin capsule for weighing out sodium and calcium in determining their equivalent weights and the results have been very satisfactory. It is evident that the data obtained from the experiment outlined above may also be used for the determination of the equivalent weight of each of the metals that was used.

In place of the usual expensive sodium press we used a very efficient substitute, made in our laboratory by Mr. E. H. Park.

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It was made as follows: A piece of 3-8 inch gas pipe 2 inches long was reamed out with a 15-32 inch drill. On one end a pipe-cap was screwed. A steel plunger 2 1-2 inches long and 29-64 inches in diameter exactly fitted into the above cylinder. A 1-8 inch hole was drilled through the side of the capped end of the cylinder so it just cleared the inside end of the cap. The clean, dry cylinder was filled with bright sodium and the plunger forced in with a vise or by driving it in with a hammer, the closed end being placed on a block of iron. The sodium was forced through the small hole in wire-like form.

PEDAGOGICAL FALLACIES IN TEACHING PHYSICS.

By J. GARRETT KEMP,

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The pedagogical fallacies practiced by some teachers of physics, and often found in apparently well written textbooks of physics, are exceedingly unworthy of any attempt to offer apologies.

Students at the mercy of such teachers and textbooks do not know why the subject is so difficult for them to grasp when the learning process is interrupted by the unlearning process. In other words, part of the students' efforts are employed in learning some physical terms and their associated concepts correctly, and part of their efforts worse than wasted in unlearning what has been obtained incorrectly, if despair has not entirely gained complete possession. I shall endeavor to point out some of the fallacies just to show that they exist and merely suggest the consequences.

Mass and weight, for instance, are used indiscriminately, no matter whether the teacher or textbook means the quantity of matter or the force of attraction exerted by the earth upon a body. Sometimes this is due to ordinary ignorance, and at other times to carelessness or mental laziness.

Why should one say merely grams instead of grams mass or grams weight—the former meaning quantity of matter and the latter a force? No one would be satisfied to take a check in payment of an account which is signed with only the given name of the payer. The result of this sort of pedagogical fallacies is found in the following: Density is correctly defined as the quantity of matter in a unit volume or the mass per unit volume of a substance. It is true that the weight of a body divided by its volume will give a number which is approxi-

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mately the same as that for the density of the body. Why should the density of a body be defined as its weight per unit volume, which means a force divided by a volume, when it is desired to convey the idea of the quantity of matter in a unit volume of a body? There is made no clear definite distinction between specific gravity and density in some textbooks. Density in grams mass per cubic centimeter has the same number as specific gravity merely because the mass of a cubic centimeter of water at standard conditions is taken as unity. Specific gravity is often incompletely defined as the relative density of a substance when it should be defined as the relative density of a substance as compared with the density of a standard substance; however, even this latter definition, while complete, is insufficiently definite to give a clear concise meaning. The specific gravity of a substance should be defined as the ratio of the density of the substance to the density of a standard substance. This definition indicates that the density of a substance may be found by multiplying the specific gravity by the density of the standard substance.

The following questionable definitions for specific gravity are often found in textbooks: "The ratio of the weight of the substance to the weight of an equal volume of water; and the weight in air divided by the loss in weight when immersed in water." These definitions are correct only in so far as they give the numerical value of specific gravity of a substance; however, they do not give sufficient information in themselves to determine the density of a substance when the specific gravity and the density of the standard substance are known. The student is even more at sea when water is not used as the standard since at times it is more convenient to use a gas, such as hydrogen.

Some textbooks present the subject of specific gravity in connection with Archimedes' principle in such a manner that the real significance of the principle is buried in wrong notions of specific gravity, and, moreover, the undue emphasis given to this presentation by the relatively large amount of space in the text creates erroneous ideas concerning its importance. The general impressions resulting from this study prevent the student from understanding the real significance of Archimedes' principle, because of the failure to properly emphasize the fact that it is merely used to determine the volume of regular or irregular shaped bodies readily. This principle is used to

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determine the density of a body in grams per cubic centimeter; however, if the British system of units were used, the student would soon understand that it is not the same as the specific gravity and is not equal to the ratio of the weight of the body in air to its loss of weight in water when totally immersed. In the metric system of units the loss of weight in water of an immersed body, or its buoyant force, has approximately the same number of grams weight as cubic centimeters of volume of displaced water, since the density of water is taken as unity, but when the British system of units is used, the buoyant force must be divided by the density of water, 62.4 pounds mass per cubic foot. How can we expect a student to find his way out of this mental maze?

The word gravity as used in physics is only a part of the phrase "force of gravity" and when it is used alone should convey the idea of a force. The acceleration due to the force of gravity is often called "gravity," nevertheless acceleration is the time rate of change of velocity which is caused by a force. The true physical meaning of acceleration is one of the most difficult of physical concepts for students to grasp, yet the stumbling block just mentioned is deliberately thrown in the way.

The law of conservation of energy is put into such glib language that very little mental effort is required to grasp its true significance, if the student is capable of thinking in terms of the universe and of indestructibility. Energy is indestructible, the total amount of energy in the universe is never changed, are several of those most used without any concrete application. When the study of simple machines is reached, instead of applying the law of conservation of energy to those assumed ideal machines the "work principle" or "input equals output" is used with no reference to the fact that the principle is merely a restatement of the conservation law. Practically less than ten per cent of the textbooks on elementary physics mention anything about the availability and unavailability of energy. That energy is indestructible is as near meaningless to the student as anything can be, is self-evident to any real teacher of physics; however, the truly practical idea of unavailability of energy, which demands much intense activity of the mind and fills up a vital discontinuity in the learning process, is almost utterly neglected. It seems that mere skeletons of words without living purpose are being taught in place of those essential physical concepts that make the physical world a place of in-

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tense interest and beauty because of genuine knowledge concerning it. The student must needs wonder at the much ado about the law of conservation of energy and the heralded importance of it when there is such little earthly application to show him the truth of these assertions. The student must of necessity think that the law is some celestial idea applicable only to that which is perfect by those who are perfect. I should like to see elementary textbooks bring this great and useful law to earth where we live and learn.

The term pressure seems to be used in various ways to mislead the student. It is defined as the force acting upon a unit area, yet some well written textbooks use the term pressure to convey the idea of a force that presses bodies together, or as a force which produces compression, and, quite often, as the force produced by pressure. Sometimes statements made in textbooks concerning friction refer to the force normal to the plane of motion as the pressure, and, in dealing with the hydrostatic force exerted upon the bottom or sides of a vessel due to the contained liquid, it is called total pressure. There is one and only one meaning which should be conveyed by the term pressure and that is the force per unit area. How can a student tell what is meant when the same term is used to express different ideas?

The term power is correctly defined as the time rate of doing work, or the time rate of expending energy. It is used, however, to convey very indefinite ideas such as capacity to do, capability, and even a force in addition to its true meaning.

If the fundamental purpose of such textbooks were to prevent or at least hinder the learning process rather than to foster and nurture it, one could easily compliment the authors and envy them too in their success. The question: "Why is physics so difficult?" is easily answered without blaming mathematics.

I shall pass over many other instances of this form of sophistry too numerous to even mention lest I tire you with too lengthy and monotonous discussion.

In closing, let it suffice to merely mention the fact that "If there were no ears to hear there would be no sound," and "If there were no eyes to see there would be no light," are expressions worthy of their place in the study of psychology; however, in physics we find it necessary to construct ears to hear sounds and eyes to see light to which our natural organs are insensible.

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Let this discussion suffice for high school and elementary college physics and let me merely mention the fact that much may be said concerning advanced physics as taught in our colleges and in our universities.

Physics seems to lead all other exact sciences in tolerating pedagogical fallacies and in suffering untold deliberate neglect on account of the forms of sophistry practiced. If those who teach physics consider it an exact science, why not endeavor to be exact in the teaching process?

"O consistency, thou art a jewel."

PETRI DISH PROJECTS IN BIOLOGY.

By G. B. Claycomb,

High School, Missoula, Montana.

One phase of the biology work in the Missoula County High School has been so successful and helpful to the pupils that its discussion here seems justifiable.

In connection with the study of bacteria, each member of the class chose a problem interesting to himself which he could work out with culture medium in Petri dishes. The nutrient agar-agar medium was prepared during the regular laboratory period by two of the boys according to the following general formula:

Water	1 liter
Liebig's extract of beef	10 grams
Common salt	10 grams
Peptone	10 grams
Agar-agar	10 grams

The beef extract was dissolved in the liter of water. The agar was cut into small pieces, and along with the salt and peptone, added to the solution. The mixture with the pan was then weighed and heated until the agar was completely dissolved. Water was then added until the original weight was restored. Enough sodium hydroxide solution was introduced to make the medium slightly alkaline, as indicated by litmus paper. The solution was filtered while hot in the steam of a sterilizer. The flasks containing the medium were plugged with absorbent cotton and thoroughly sterilized.

About twenty cubic centimeters of the hot medium was transferred by means of a pipette to each of the sterilized Petri dishes. The dishes and their contents were sterilized in steam for about thirty minutes on three successive days. This last treatment was thoroughly done to prevent the development of colonies from spores. The dishes were then ready for use.

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After use, the dishes were put in a warm, dark place.

The projects were mostly of the pupils' own selection. The following list will give a good idea of the nature of the subjects chosen:

The relative number of bacteria in pasteurized and unpasteurized milk.

A comparative study of bacteria in Missoula river water and tap water.

Bacteria on the fingers before and after washing.

Effect of heat on the growth of bacteria.

How does light affect the growth of bacteria?

The effect of low temperature on the growth of bacteria.

Bacteria in the air of a room after sweeping with a broom and with a vacuum cleaner.

The value of the use of sweeping compound in reducing the number of bacteria in school room air.

The effectiveness of common disinfectants and antiseptics.

The value of salt, sugar, and vinegar as preservatives.

The value of keeping the teeth clean. Bacteria on the teeth.

Should animals be kept in the house? Bacteria on dog and cat hair.

Should snow be eaten? Bacteria in snow.

Bacteria on a soiled handkerchief.

Should girls put their hair in their mouths? Bacteria on human hair.

Bacteria on coins and paper money, pencils and erasers.

All these and other projects were worked successfully by the members of the class.

Other problems will suggest themselves to anyone taking up this kind of work. Some that come to mind are as follows:

Are bacteria thrown out by a person having a cold, in coughing and sneezing?

Do tooth brushes need to be sterilized occasionally?

Should clothes be brushed in the house?

Does boiling water kill the germs in it?

Do flies carry bacteria on their feet?

Does freezing kill bacteria?

The following descriptions of the experiments performed, taken from the students' notebooks, will give a good idea of the reaction to the work:

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PROBLEM.

To determine the relative number of bacteria in the air of a room during dry sweeping and vacuum cleaning.

METHODS AND OBSERVATIONS.

I exposed a Petri dish containing an agar medium for five minutes in a room during the process of dry sweeping. Several days later I exposed another Petri dish for five minutes in the same room while the vacuum cleaner was being used. The dishes were placed in a warm dark place. About five days after exposure colonies of bacteria appeared in the dishes. I observed that a great many more colonies of bacteria developed in the Petri dish which had been exposed in the room swept with a broom than in the room swept with the vacuum cleaner.

CONCLUSIONS.

I have concluded that the vacuum cleaner should be used whenever possible. It should come into common use and if possible should exterminate the use of the broom.

PROBLEM.

Are bacteria present on cat hair?

METHODS AND OBSERVATIONS.

Several hairs were carefully taken from a pet cat and placed in a Petri dish containing agar culture medium. The dish was placed in a warm dark place and allowed to remain there several days before examination. After several days the Petri dish was examined and found to contain many colonies of bacteria. Some of these colonies were white, some were yellow, some were black and some were orange.

CONCLUSIONS.

I conclude that cats carry a great many bacteria and, unless bathed very often, should not be kept as pets in the house.

PROBLEM.

To determine whether bacteria are present on such common things as coins, and the points and erasers of pencils.

METHODS AND OBSERVATIONS.

A coin was touched in a Petri dish containing agar culture medium. The same took place with the point and eraser of a pencil. The dish was then placed in a dark, warm place. After four or five days I observed that the colonies of bacteria began to appear. The next time I observed that the bacteria had taken a certain shape, that being round and irregular, and that they had certain colors, those being yellow, white, and orange.

CONCLUSIONS.

I conclude that coins, points or erasers of pencils should not be put in a person's mouth. This is not only a bad habit, but the bacteria may also be harmful.

PROBLEM.

Does washing reduce the number of bacteria on the hands?

METHODS AND OBSERVATIONS.

After coming down stairs with my hand on the banister, I touched my finger in three places on the agar-agar in a Petri dish. I then washed my hands well with soap and touched another finger to the agar-agar in another dish. The dishes were then put in a warm dark place. When I examined the dishes after a few days I found many colonies of bacteria where I touched my finger before washing, but none where I touched my finger after washing.

CONCLUSIONS.

I conclude that washing frees the hands of bacteria, and that the hands should be washed often, especially before meals.

Each pupil was required to exhibit the results of his experiment, and describe and discuss his project before the other members of the class. This brought each problem to the per-

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sonal attention of the class and enabled them to receive some benefit from the work of the others. Some of the boys manifested their interest by taking photographs of their Petri dishes after the colonies had developed. All the pupils seemed to feel that this kind of work was something worth while.

THE GRAPH OF THE UNIT PARABOLA.

By J. R. Sage, Jr.,
Iowa State College.

In teaching, we frequently use the unit parabola

$$y = x^2+bx+c \qquad (1)$$

where b and c are any integers, to illustrate various points in graphical solution and theory of equations, and we wish to be able to write without hesitation the equation of a parabola of the above form which will exhibit the properties under discussion. For instance, we may wish to illustrate the fact that the roots of an equation of the type $y = f(x)$ are the abscissas of the points where the graph of $f(x)$ intersects the x-axis. After writing our equation it is also of advantage to be able to sketch its graph quickly.

Now (1) may be written in the form

$$y = (x+b/2)^2+c-\frac{b^2}{4} \qquad (2)$$

showing that y is a minimum for $x = -b/2$ since $(x+b/2)^2$ is either zero or positive. Also, if $c = b^2/4 = (b/2)^2$, the right hand member of (2) is a perfect square and (1) has a double root, $-b/2$.

Graphically, this means that if c is chosen equal to $(b/2)^2$, the x-axis will be a horizontal tangent to the parabola at its vertex $(-b/2, 0)$. Then in order to have the vertex of the parabola fall below the x-axis, so that the graph will intersect the axis in two points, it is only necessary to choose a value for c less than that which would complete the square whose first two terms are x^2+bx. If c is k units greater or less than $(b/2)^2$, the vertex will be at $(-b/2, k)$ or $(-b/2, -k)$ respectively. If b is even, $(b/2)^2$ is integral and the coordinates of the vertex are integral. If b is odd, $(b/2)^2$ is not integral, the abscissa of the vertex is midway between two successive integers, and the ordinate of the vertex is one fourth unit less than some integer (K integral.)

Suppose it is desired to write the equation, having two distinct real roots, of a parabola of the above form, the abscissa

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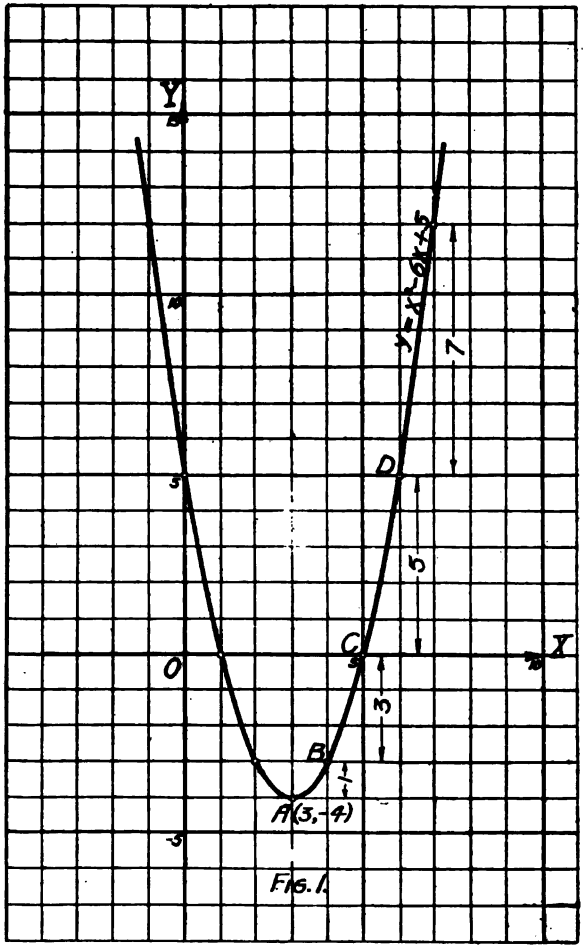
of whose vertex is 3. The first two terms of the function must be x^2-6x, the completed square of which is x^2-6x+9, a function whose graph would just touch the x-axis at the point (3, 0). But if c be changed from 9 to 5 the value of y for every value of x is decreased by four units and the vertex falls at (3, −4). Fig. 1 shows the graph of

$$y = x^2-6x+5 \qquad (3)$$

with vertex as stated above.



Now if a table of values of y in the general unit parabola be computed using equal x intervals, it will be found that the second differences of the y values will be constant and con-

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sequently the first differences will be in arithmetical progression. If the x intervals are one unit, the second differences are two. This fact can be used in quickly determining sufficient points to sketch the graph.

Two cases arise, depending upon whether b is even or odd.

Case 1, b even. If b is even, we may begin at the vertex, A, Fig. 1 (which is easily determined as shown above), and going to

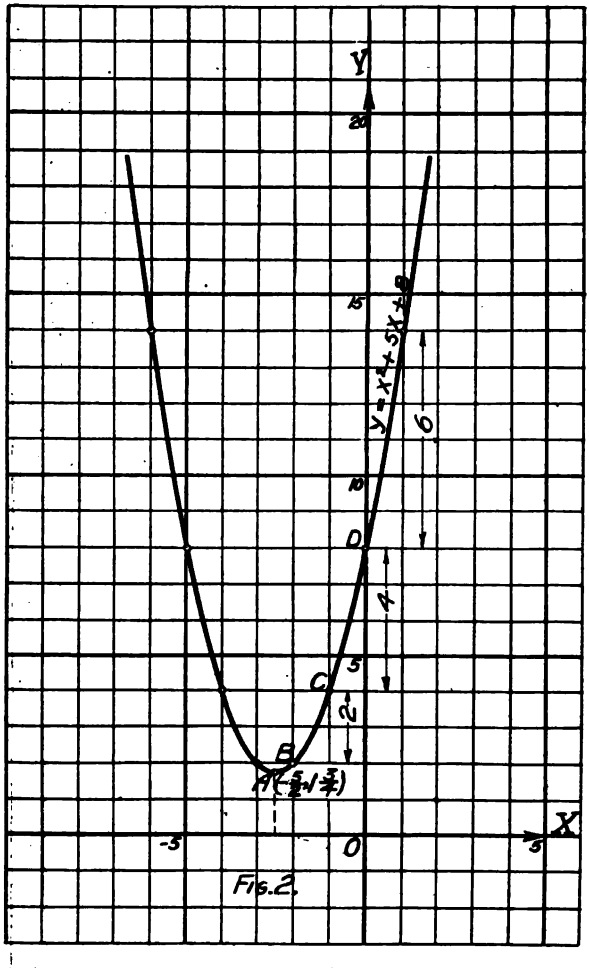

Fig. 2.

the right one unit and up one unit locate a second point, B, whose coordinates are integral. Then from B going to the right one unit and up three units we locate C, a third point on our graph. From C we go to the right one unit and up five units and so on, beginning at the vertex and going from point to point,

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in each case increasing x by unity, the increments of y being the series of odd numbers, 1, 3, 5, 7, 9, ... In this way we may determine as many points as desired and sketch the parabola, also making use of the fact that the curve is symmetrical with respect to the line $x = -b/2$.

Case 2, b odd. We now use the graph of $y = x^2+5x+8$ to illustrate this case. (See Fig. 2.) The ordinate of the vertex is $c-(b/2)^2 = 8-25/4 = 1\frac{3}{4}$. Therefore, the vertex is at $(-5/2, 1\frac{3}{4})$.

Since the shape of the unit parabola is independent of b, we might start at the vertex as in Case 1, and locate successive points, but no point so determined would have integral coordinates. If, however, we start at the vertex and go to the right half a unit and then up one fourth of a unit, we locate a point B, Fig. 2, on our locus having integral coordinates. Then going from B one unit to the right and up two units we determine C. From C increase x by unity and y by four units to locate D, the increments of x, beginning with the point B, being unity and those of y being the series of even numbers 2, 4, 6, 8, . . . , all points so located having integral coordinates.

AN OUT-OF-DOOR SCIENCE CLUB FOR HIGH SCHOOL STUDENTS.[1]

By LEON D. PEASLEE,

Public Museum, Milwaukee, Wis.

It is a generally recognized fact that the more interest in his subject a teacher can instil in pupils, the better the results obtained. Moreover, there is usually a desire on the part of the pupil, as well as the teacher, to go more deeply into certain topics of interest than time will permit in the classroom. For this reason, various organizations such as science clubs, history clubs, English clubs, etc., have been formed in most high schools. As science club work is the object of this paper, clubs other than those dealing with science proper will be omitted in the following discussion.

The writer has made a close study of high school and college science clubs for a considerable number of years and while he is firmly convinced that they are not only valuable but absolutely necessary for the proper teaching of science, still he feels that the difficulties under which most of these clubs operate

[1]Read before the Wisconsin Teachers' Association, November 2, 1916.

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do not permit of that one phase of natural science work which is, perhaps, the most important of all, the study of nature in the great out-of-doors.

The membership of many clubs is made up of students from all the various science classes. Hence the average program must, of necessity, be of particular interest to certain groups of students rather than to the club as a whole. Moreover, meetings are almost invariably held after school hours; a time which is not overly conducive to student interest. There are, also, so many other things going on at this time, such as football, baseball and track team practice, recitals, business meetings, etc., that many members of a club that meets after school are bound to be absent. This is also responsible for causing many a good student to refrain from joining.

Because of the varying interests of its membership, the usual time of holding meetings and other reasons which need not be mentioned here, we see, then, that the average high school science club does not make it possible for its members who are particularly interested in nature study to go deeply into subjects of especial interest or make much, if any, out-of-door study.

With this point of view for guidance, the Educational Department of the Public Museum of Milwaukee organized in 1912 a science club for high school students which it hoped would offer to those who became its members an opportunity to go more deeply into natural history topics than either their school courses of study or their high school science clubs permitted, and to get out into the open to study nature first hand.

The process of organization and the results obtained in this club are made the basis of this paper. Nothing is included or suggested that has not been tried out in this society, which is known as "The Milwaukee Science Club."

As we have seen, it is useless to undertake an out-of-door club for high school students unless a suitable time for the same can be found. It is evident that it will be impossible to get the students to make field trips after hours upon school days, and, as Sunday is out of the question, Saturday alone remains. This, too, seems uninviting. Students who have been to school all the week are not inclined to enter into anything which looks like more school upon Saturdays, and besides, many find it necessary to work upon this day. Moreover, most all athletic contests, debates, entertainments and other amusements come either upon Friday evening or Saturday and at either time it

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would be a hindrance. In spite of all these objections, Saturday morning is about the only possible time for meetings, and as experience has proven it is quite satisfactory, we may set aside that difficulty and proceed to the problem of membership.

Such a club will, of course, appeal only to a certain type of students. It will attract as a rule only those who are particularly interested in the natural sciences, and of these only those who have the time to spare upon Saturdays and who can see that what they are to do is to be far separated from school work.

The question as to whether or not both boys and girls should be admitted to membership in the same club is one which will have to be worked out in the individual cases. It may be mentioned, however, that generally speaking it does not seem advisable. There is the possibility that the club will develop into a social organization instead of one mainly for the study of science, if both sexes are included. With those students who are entirely sincere in their desire for such work there is little danger of this happening, but there are many who would artfully deceive even themselves into believing they had an exceptional interest in science if, by so doing, there was to be obtained the privilege of taking weekly walks into the fields and woods with their friends. Then there must also be taken into consideration the fact that the young ladies are generally capable of less endurance than the young men, and in a club which spends most of its time outside, that while the one will seem to always be holding back, the other will invariably seem to be trying to overdo. It was this fact alone which resulted in the Milwaukee Science Club becoming one solely for boys. Long, all-day tramps, perhaps in the dead of winter, and even during severe snowstorms, did not appeal to the girls, and as it was not possible to arrange for two kinds of work to go on at the same time, they gradually dropped out.

It is best to offer no incentive to obtain members other than the direct benefits to be derived. It so often happens that teachers excuse from examinations or give extra credit for such work in order to obtain members, and while this may serve its purpose, it attracts many who are not the best type of members, and tends to put a mercenary aspect upon the work even in the minds of the best students. There should be absolutely no relation between the club and the school through which the members might expect credit in any form from their teachers. Neither should there be any attempt to offer amusements to attract

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or hold them. Except in unusual cases, a sufficient membership may be obtained simply by the opportunity of congenial friendships and an easy way of getting valuable information by a process so far divorced from the classroom method that it becomes a pleasure and not a task.

The selection of the new members should be very carefully carried out. Names may be suggested by the teacher or the members may be encouraged to scout out the desirable ones for themselves. In either case "the office should seek the man" and the club ought always to reserve the right to invite others to become candidates for admission. No one should be hastily taken in. The prospective member may be required to attend a considerable number of meetings (at least four) before his name is voted upon. During this time the members may have an opportunity to determine whether or not they consider him truly interested in the work of the club and a young man of desirable character, and at the same time he can determine whether or not he sincerely wishes to join.

Although there is, of course, a desire to have as large a membership as possible, still it is advisable to limit the number in the club at any one time to approximately twenty-five. No absolute limit should be set, however, for in case this is done there is sure to turn up just when the full quota has been obtained some student who would make an exceptionally valuable member. With many more than the above mentioned number the club becomes unwieldy in the field, and the members cease to obtain the element of personal association with and instruction from the advisor.

There is another problem of membership which will appear as soon as the club becomes well established, and that is, that many of the students who join when they are taking science work will wish to continue as active members while they are in school. A slogan which should always be encouraged is "Once a member always a member." It takes more than one year for the club to have its greatest influence upon the students, so the organization should be perfected in such a manner that it will hold its members as long as they are in the school, and even after that they should always be welcome.

With a membership made up of students perhaps from all four classes, it is true that a certain number who might wish to join will be ruled out. Still, if the results to be obtained are to be as far reaching as possible, the number must of necessity be lim-

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ited. As there is no relation between the club and class work, there is no obligation to take in any more members than are desired, and consequently only the cream of the science students need be selected. It will soon become an honor to be a member of such a select society and no difficulty should be experienced in obtaining just the members desired.

Once the club is well under way, it is best to definitely organize according to recognized customs. A constitution vesting the entire control of the organization in the hands of its members should be adopted and officers chosen. Officers are best elected for a term of one year and should not be eligible to reelection to the same office. A short formal meeting held before each week's program will add to the dignity of the club. This may be either at the place of assembling or at some convenient point in the field.

The club should have a definite object and this may well be stated in some expression which can be considered as a motto. The motto of the Milwaukee Science Club leaves no question as to the purpose of that organization. It reads: "Study and Preserve the Works of Nature, Not Destroy Them."

After the officers have been elected and installed, the advisor should insist upon being considered simply as one of the members and claim no privileges not enjoyed by any of the others. In his position as advisor the members will naturally come to him for information they may desire, and while he always gives this freely, he should not use this influence unduly to control matters purely of club nature. Once the management of the club comes too directly under the influence of the advisor, it falls to the plane of the school society which is controlled, and often presided over by teachers. Such a condition can be only detrimental.

The kind of work which is selected and the way in which it is conducted has much to do with the success to be obtained. There is no end of interesting subjects which may be chosen and all may be treated in a way that will not savor of the classroom in any manner. In all this work there should be no attempt to require the actual memorizing of anything. All that is to be learned may be gradually acquired by the process of repetition. The members must be led to feel an interest in all nature, and whenever they come across anything which is at all out of the ordinary, or which they have not seen for some time, they will develop the habit of taking pleasure in calling attention to it

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themselves. If they can recall the name and facts concerning the thing in question, they should do so without prompting by the advisor. In case they cannot, they must be encouraged to ask, and to continue to ask as often as they come across the same thing, until it becomes well fixed in their minds. In this manner much can be learned without taxing the memory in the slightest. As new members come into the club it will be noted that the older ones unconsciously take upon themselves the answering of the greater part of the questions, and the work becomes almost automatic; questions being asked of the advisor only when the information cannot be given by some member. This method is unique and the students enjoy the responsibility thus placed upon them.

As for the nature of the actual work of the club there are many possibilities. As the name signifies, the greater part of the activities should be out of doors, but provision must be made for inclement weather and particularly for the winter months when it is not always possible to get out.

In the beginning, no definite program of field work ought to be undertaken. Trips to the parks, fields and woods, as the desires of the members shall dictate, may be taken, and every effort made to make them interesting to all. A congenial friendship among the members must be of first importance, and these "walks and talks" will greatly facilitate this. The advisor should accompany the boys on all these trips and should aim to gradually develop their interest in the various phases of natural history which they encounter.

At first the social side of the club will probably dominate, and the trips will seem chiefly for pleasure, but before long the trend of thought will gradually turn into the desired channels. In an amazingly short time, with the aid of the advisor, the members will become acquainted with the trees, shrubs, wild flowers, birds, common rocks, geological formations, etc. They will, moreover, develop a marked pride in this newly acquired information, and will exert themselves in seeking out new facts, as well as handing down those already obtained to the new members who are just beginning the work.

All-day hikes taken from time to time also tend to hold the interest of the members, and these may be taken in the winter as well as in the summer. One will be surprised to see with what enthusiasm such a group of nature lovers will start out upon a twenty mile walk in the midst of a blinding snowstorm, and yet

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he can readily see that the winter woodcraft which the boys learn will repay them for the hardships they endure.

As the various places to which the club can go in the short space of a morning are limited, it will be well in due time to undertake a more comprehensive study of individual localities. Zoological, botanical and geological surveys can be made without much trouble after the club becomes fairly well acquainted with the natural surroundings of the vicinity. A simple plane-table may be made and used to obtain suitable maps; the streams, swamps, hills, valleys, bluffs, etc., may be recorded; the flowers, shrubs and trees listed and the locations where the more interesting of these can be found shown upon the maps; even microscopic surveys of the pond and brook life may be worked out and included. Such a series of maps as these and their accompanying short descriptions if put in booklet form would not only be a credit to their makers but also of greatest value to the public in general and to teachers in particular.

During the winter months various programs can be arranged which will hold the interest of the members. Some winter field trips ought to be taken but as a whole the rigors of a cold climate will greatly reduce the roll call if such trips are made the rule. As the club is naturally interested in anything which is founded upon scientific principles, much of one winter may be spent in making a study of the various manufacturing plants of the vicinity. The boys will readily see the value of such trips, as they not only supply much interesting information but also material for the basis of many an English theme.

Another interesting line of winter work may be made possible by reserving the microscopic analysis of the brook and pond water until that time. If the club can have access to a laboratory and microscopes, mason jars of water, mud and dead leaves could be collected from various localities before the cold weather sets in and placed upon the laboratory window-sills for future reference. Before long these will be found to be teeming with a great variety of plant and animal life, and throughout the coldest weather much interest can be aroused in finding, studying and recording these minute forms of life.

It may be well to encourage certain students to undertake definite problems. The thorn-apple, sparrows, wild sunflowers, or ants of the neighborhood may need attention, and material and notes gathered at favorable times may be worked up during

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the winter. This work will, of course, require serious thought, and while the majority may not care to undertake it there should be some to whom it will appeal particularly.

If the advisor has the time and the inclination, one of the most interesting and at the same time most valuable of winter activities may be a series of talks given by him upon some topic which the club may select. There is an opportunity here to do a wonderful amount of good if these talks are properly conducted. Human anatomy, physiology, embryology and sex hygiene are but a few of the many subjects which will appeal to all young men. In the giving of these talks one can go far beyond the possibilities offered in the classroom and can thus supply a much needed want.

The advisability of discussing these, or any other subjects in fact, need not be raised, for the young men have already passed the age of morbid curiosity and have reached that of sincere desire for knowledge. They have reached a period when they should thoroughly understand the human body and its functions. They cannot get this in the meagre courses offered in our high schools, and their parents are seldom in a position to enlighten them. Who else, then, than one who has walked with them, talked with them and perhaps camped with them, could be better fitted for the imparting of this knowledge? Moreover, such an undertaking will not only meet with the hearty approval but even the urgent desires of most parents who will readily see the exceptional value of talks of this kind.

The spring and fall months, as we have seen, should be chiefly spent out of doors; the winter months are well suited for various indoor activities; lastly we must not forget the summer vacation. During this time it will not be advisable to attempt to hold regular weekly meetings and the activities should cease entirely except, perhaps, for occasional all-day hikes, unless a definite camping trip can be undertaken.

If such a trip is contemplated, the plans ought to be laid long before hand. For the best results a stay of fully three weeks should be arranged; and the site selected should be upon the forested shore of some lake or waterway as far as convenient from civilization.

Experience has shown that the expenses of an undertaking of this kind, when the distance does not exceed two hundred and fifty miles, and the stay three weeks, need not be over twenty-one dollars per member. This should cover carfare (without

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sleepers, as the boys are going camping anyway), boat rental, three meals a day (and growing boys are good eaters, too), and all other accessories. To raise the money for a camping trip the boys should start saving early. A banking system can be worked out among the members themselves and small deposits made weekly. During a part of the summer many will doubtless obtain regular positions to make up the difference.

How close the boys can get back to nature and what a wonderful experience it will be for them can only be realized by one who has actually tried the experiment. The hardships of a long tedious hike with heavy packs, or the steady pull of the oars hour after hour; the pitching of the camp; the sleeping upon balsam beds; the controversy with mosquitoes, deerflies and other of nature's pests; the cooking of their own meals and the eating what they have cooked, mingled with the pleasures of fishing, bathing, hiking, exploring and the most congenial of comradeships, make camping a fitting climax for the activities of an out-of-door science club.

With facts such as these in mind, one cannot hesitate to agree that an out-of-door science club for high school students is both possible and desirable. The benefits are far reaching. Such activities are exceptionally educational and broadening. The walks through the fields and woods and the experiences of camp life truly open before the boys the doors of nature, disclosing a world of interesting things that will be a pleasure to them as long as they live.

In this practical age every business enterprise one understands, whether it be the making of soap, candy, brooms or automobiles, the reading of the weather or the conducting of a police court trial, is one more rung in the ladder of individual progress.

The human body is a most wonderful and intricate organism, yet how little we know about its vital functions. What study and care we give to the delicate mechanism of our gun or auto while we carelessly leave our bodies to care for themselves. A comprehensive study of the body and its functions cannot help but be of greatest good to maturing boys, and the vigor with which they attack such serious problems, the frankness with which they ask the many questions which they have hesitated even to suggest to their parents, and the readiness with which they assimilate the valuable lessons taught will, in themselves, amply repay for all his efforts, him who gives his valued time to such a club.

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ACOUSTIC ATTRACTION AND REPULSION.

C. C. KIPLINGER,
Ames, Iowa.

Much of our knowledge of wave motion is based upon the study of acoustics. A sound wave is an easily demonstrable vibration of a well known elastic medium, air. Hence, in acoustic attraction and repulsion, the properties of both the vibrating medium and the vibration are well known.

Guyot, Guthrie and Shellbach observed independently that a sounding body in a state of vibration attracts or repels objects near it. It was concluded from experiments of this kind that "the vibrations of an elastic medium attract bodies which are specifically heavier than itself and repel those that are specifically lighter."

For example, if a strip of paper is suspended at one end and a vibrating tuning fork is brought near it, the paper moves toward the fork. Air is the vibrating medium and the vibrations are composed of alternate compressions and rarefactions. Guthrie found that the air about the prong of a vibrating tuning fork is expanded. Hence, the paper is attracted to the fork owing to the difference of pressure on its two faces; the lesser pressure being on the side nearest the fork. Therefore, we may conclude that vibrations in an elastic medium cause expansion of the medium and that attraction, in some instances at least, is a function of pressure differences.

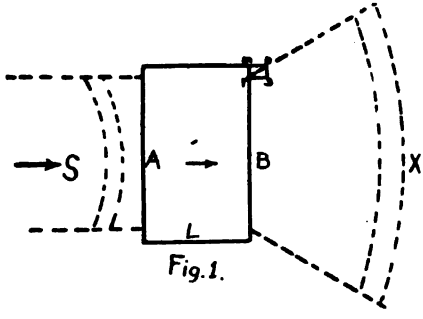

Fig. 1.

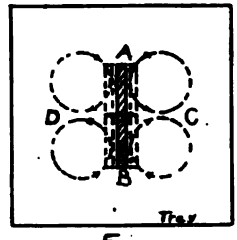

Fig. 3.

On the other hand, we read in "Ganot's Physics," Ed. 17, page 282, that a balloon of gold-beaters skin filled with hydrogen and tied down by a thread is repelled by a resonance box on which a tuning fork is vibrating. This may also be explained on the basis of pressure difference. In Figure 1, L is the hydrogen lens, with the walls A and B of thin membranous material. A sound wave, S, impinging on L is refracted outward, owing

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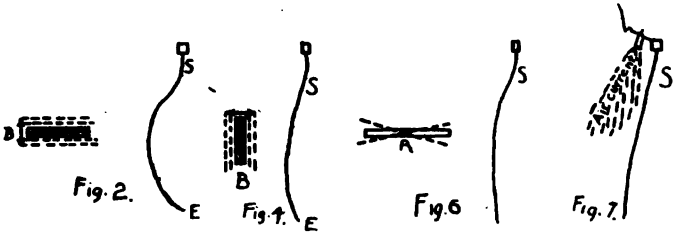
to the relatively small density of hydrogen; L behaving like a conclave lens. The wave S exerts pressure on A. Since the wave is bent outward at B, the force due to the wave pressure may be resolved into two components, one parallel to B, and one perpendicular to it.

In other words, the force normal to the surface at B is less than at A, these unbalanced pressures resulting in movement toward X. Hence, we may have repulsion resulting from a difference in pressure. Therefore, it would seem to follow that a freely moving body in an elastic medium, different portions of which are, for some reason or other, at different densities, will always tend to move toward the region of least pressure.

This is true in the case of bodies floating on the surface of a liquid. Two bodies, both of which are, or are not, wet by the liquid, mutually attract each other, owing to the lessened pressure between them. If the liquid wets one and does not wet the other, the pressure between them is increased and repulsion results. Again we find attraction and repulsion to be functions of pressure differences.



Procure a strip of paper about two inches wide and three feet long, also a small piece of board; the top of a cigar box will do nicely. Fasten the strip at one end to some convenient support, so that it hangs freely. Then take the board and cause it to move up and down as rapidly as possible near the paper, as shown in Figure 2. The paper will move toward the board. The air has been set in motion and pressure differences have been created, resulting in the attraction of the strip. The bending of the paper away from the board at E shows that an air current traveling in that direction is producing increased pressure and hence repelling the strip.

The production of currents by an object vibrating in a fluid may be shown as follows: Fill a rather large tray about two-thirds full of water and dust some lycopodium powder, or cork filings, over its surface. Procure a glass strip and hold it so that one edge is slightly below the surface of the water. Now move it rapidly to and fro through a short distance.

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Observe the direction of the currents formed. They flow in at both ends of the strip and out at the center, Figure 3. Hence, we find that the strip of glass is attracting particles at A and B and repelling them at C and D, owing to the currents produced by vibrations. However, water is only slightly compressible. For this reason the phenomena of vibrations in air differ from those in the former fluid.

To illustrate. Cause the board of experiment one, Figure 2, to rapidly approach and recede from the paper band. The band approaches the board, as before, Figure 4. The curious thing here is that the rapid movement of the board toward the paper causes the latter to approach the former in turn.

What takes place as the board nears the strip? Let us illustrate by another experiment. Cause the board to rapidly approach the rather tall flame (luminous) of a Bunsen burner. The flame darts toward the board, Figure 5, A. Now cause the board to rapidly recede. The flame follows the board, Figure 5, B. Attraction results in each case. Now strike at the flame with the board, suddenly arresting its progress just as it almost touches the flame. For an instant only, the middle portion of the flame bends away from the board, Figure 5, D.

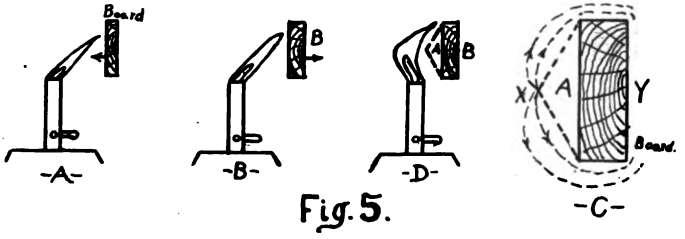

Fig. 5.

Figure 5, C, shows what has probably taken place. Upon moving B rapidly through the air in the direction shown, the air nearest the board piles up on its surface and is slightly compressed. Hence, it is this pyramid of relatively denser air that bends the flame outward at D, Figure 5. The air further away from the center of the board spills over its edges and produces a region of lessened pressure at X. The movement of the board away from Y produces lessened pressure in this region. The air flows from X, tending to restore normal pressure at Y. Thus the movement of the flame toward the board, whether the latter is receding or approaching, is due to pressure differences caused by this motion.

A vibrating tuning fork will attract a strip of paper in its

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vicinity, not only if the face of a vibrating prong be brought near the paper, but also, although to a less marked degree, if the ends are approached to it. This may be illustrated by rapidly vibrating an ordinary foot rule between the thumb and fingers, and holding one end near a strip of paper, Figure 6. The paper is attracted as before. The air forced off the end of the rule toward S does not balance the decreased pressure due to the movement of R through the air.

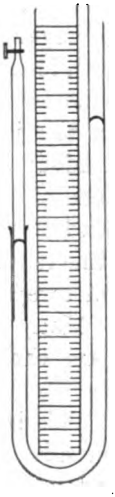
If, as in Figure 6, we take a tube and blow a current of air through it, the paper can be made to follow the current, upon changing the direction of the latter. Hence, these experiments to indicate that attraction and repulsion in the known elastic medium, air, are functions of differences of air pressure. Moreover, they suggest that a vibrating body in an elastic medium produce those differences of pressure which result in the phenomena of attraction and repulsion.

BOYLE'S LAW APPARATUS.

By RALPH C. HARTSOUGH,
High School, Wichita, Kansas.

DESCRIPTION OF APPARATUS.

The U tube is an unequal arm glass tube. The longer arm is about 18 inches and the shorter arm is 12 inches long. In the short arm is a short glass tube about 12 inches long. This short glass tube fits snugly into the short arm of the U tube by means of appropriate packing, and is fitted with a stop cock at one end.



USE OF APPARATUS.

Mercury is used in the U tube. The confined gas in the glass tube is compressed or expanded by pushing it as a piston into the short arm of the U tube.

ADVANTAGES.

1. Small amount of mercury required.
2. Ease of manipulation.
3. Compactness, simplicity and cheapness.
4. Accuracy of readings.

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THE PRESENT STATUS OF HIGH SCHOOL SCIENCE.

By WILSON C. MORRIS,
Normal School, Warrensburg, Mo.

On page 686 in SCHOOL SCIENCE AND MATHEMATICS for November, 1916, the following statement is found: "Notwithstanding the increased importance of science as a factor in everyday life, it is a fact well known to students of education that the percentage of students studying the older sciences in our public schools is on the decline, and has been on the decline for twenty years."

Some one has said: "Facts are stubborn things." Since this is so, I shall not attempt to refute the above statement but seek for reasons why it is so.

I hope that I am not an alarmist; and yet there is cause for alarm when a formal subject like algebra holds its own while the sciences fall off. It is hard to believe, when we consider that the age in which we live is predominantly scientific. The part that science plays in modern life and all forms of modern industry is so well known to the general reader that it needs but mere mention. During the last hundred years the progress in science and industry has been very marked. The number of students in our engineering schools has increased rapidly; and yet, in the face of these facts, the older sciences, strange to say, have not held their own in our public schools.

Various reasons that are not derogatory to science can be given for this state of affairs. Many students who have done no laboratory work and therefore do not know its value are liable to regard it as irksome. I can very distinctly remember my own feelings in the matter. When I was a student at the Millersville (Pennsylvania) State Normal School, botany was *required* in the junior year. For the field and laboratory work each student was required to collect, name and mount fifty flowering plants, and to analyze and make drawing of twenty-five plants. Had the course been *elective*, the relatively large amount of time required outside of the regular recitations would have scared me away from this course.

Many of our students here do not elect science because they have the notion that if they do so they will not have time for the "school activities," on account of the laboratory work.

This is especially true of those students who are doing some outside work to help defray expenses. Again, in most schools today the science teachers make their programs out in double

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periods on account of the laboratory work. This means fewer classes; and, if the elective system is used, it will mean more conflicts for the students in classifying. Each of these factors reduces the number enrolled in the science departments.

During the past fifteen years the vocational element has gained a prominent place in our educational system. Personally, I welcome vocational education; yet, at the same time, I know it has tended to reduce the numbers enrolled in the older sciences. At least, it has in Missouri. In Missouri, today, two units of science are generally required of students graduating from first class high schools. Outside of the large city schools it is generally understood that one of these units will be agriculture. I am not questioning the validity of this. I fully realize the value of agriculture; but it seems quite natural that the older sciences should fall off in numbers when we consider that they share the time and credit formerly allotted to them with a subject so widely studied as agriculture.

I, for one, am not ready to attribute the falling off in the older sciences in the high schools entirely to the nature of the subject matter and to poor teaching; however, if it be true, as most writers on education at least infer, that the falling off is due largely to the nature of the subject matter and to the method of presentation, is it not high time for some readjustments to be made?

In pointing out some changes that I feel are needed, I shall limit myself to my own subject—physics. The argument that our high school physics is not connected closely enough with the daily life of the student is valid. We do not deal enough with "real situations." Read the preface to most any text on high school physics and you will probably find a statement somewhat like the following: "The student and his daily experiences have been uppermost in the author's mind." This is undoubtedly the right plan; but a careful examination of our high school texts will show that this plan has not been carried out in all cases. It seems hard—almost impossible—to break away from tradition; and hence much of our high school physics is still dilute university physics.

To cite a concrete case, take up the work on light. The study of light because of its part in everyday life, should be very interesting; but it is not always so. It is not unusual to see the teacher start with water-waves and ripples and from these "readily pass" to electromagnetic waves—rather a large

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step for beginners. Would it not be more fitting to start the subject of light with some homely problem as "Lamps and Reflectors"? This will lead to a study of the first cost, the energy used, the amount and kind of light given out, etc. Incidentally the student will learn various optical terms, straight line propagation, photometers and their adjustments, the law of reflection, etc. In place of spending so much time in tracing light through lenses with *pencil* and *paper* why not take up a problem like this, "A Photograph for the 'School Annual' "? This will lead to a study of the parts of the camera, the pin hole camera with and without a lens and how images are formed. Some individual experiments or classroom demonstrations with lenses will be necessary; but the experiments *now* are made to answer definite questions and to furnish information that is immediately needed. The effect of light on certain salts may now be tried. The value of the camera to science and art should be pointed out. Certain members of the class may be assigned readings for a brief report on the history and development of photography.

Space forbids a discussion of "project teaching." I think it is Professor Woodhull of Columbia University who says: "All science is project science." I have heard Professor Strayer of the same school on two different occasions convey about the same idea. In the large high schools where experienced and well-trained teachers are employed and are required to handle but one subject, the method seems admirable; but in the smaller high schools where a teacher handles physics, chemistry, an overflow class in mathematics and probably coaches the boys in outdoor athletics, serious objections may be offered to this method. In such cases it is doubtless preferable to choose a good textbook.

Coming back to the subject of light, we spend too much time on refraction and too little on color, illumination, home decoration, etc. Often in our work on light we leave the earth and soar into the realm of the ether. I must acknowledge my guilt here. A few years ago in one of the classes in light I took a little time off to tell the class about J. J. Thomson's fibrous ether, Lodge's massive ether, Larmor's ether as a basis of matter, etc. After class one of the boys hailed me with this question, "Is that the stuff you buy at the drug store?" I immediately reached the conclusion that in elementary physics, at least, it is best to remain on sure footing.

It is not only in the subject of light that we fail to connect

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the work with the student's past experience and his future needs; the same is true in electricity. We talk fluently about "a circuit." We have the students recite in parrot-like fashion amperes = volts/ohms. Can't the student get more by dealing with a "real situation" which is readily afforded by electric light circuits or electric stove circuits? I don't wish to infer that the aim is to make an electrician of the student; and yet I do believe that a student completing high school physics should know something about the installation of electric light and telephone circuits, as they are very likely to be part of his present and future surroundings.

In my judgment too much of our laboratory work in electricity is done with toys. Many of our high school students can tell much about "ebonite" and "cat's fur"; but if they were given a real problem, say the installation of a bell-system in an eight room school building, they would be like the girl who encountered a door-knocker for the first time. After she had looked at it intently for some time the lady of the house started to show her how it worked. She was not permitted to do this for the girl at once informed her that she knew what it was and how it worked but that she couldn't find the bell in it.

Likewise many of our high school students can tell all about the specific gravity of "a liquid"; but how many would be able to tell if the milk had been "watered"? Using the language of Dr. Leonard P. Ayres, "The greatest problem that the schools are facing is the lack of intimate relationship between the work of the schools and the work of the world."

From what I have said you will infer that I wish all the time spent on so-called "practical" subjects. No, I do not. It is impossible to draw a hard and fast line between pure and applied science. Those interested in the relation of these should read Gregory's book, "The Spirit and Service of Science." Personally, I think it is well to avoid extremes both in the practical and the cultural aspects of the subject. I agree with Professor Lewis in his address before the N. E. A. in 1915 on "Pure Science." He says: "We are likely to forget that children are not materialistic or utilitarian. They have imaginations which we should develop, not stifle. There is in every healthy child an innate curiosity about his surroundings which demands satisfaction, and which if developed and encouraged is the surest passport to knowledge and power. Often the colors in the soap bubble may arouse more interest than a pulley or a gas engine."

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In the choice of subject matter, opinions vary widely. Some of our best known writers on education, as Professors Dewey and Bagley, have laid down some broad principles to govern the selection of subject matter. Twiss, in Monroe's "Principles of Secondary Education," enumerates several of these principles. If we knew definitely the purpose of the high school physics, the question of subject matter would be easier to handle; but our ideas of education have changed so much in the last ten years that we find great diversity in the opinions expressed concerning the purpose of the course in high school physics. While it is perhaps impossible to lay down hard and fast principles governing the choice of subject matter in all cases, high school teachers will do well to keep in mind Professor Dewey's two words, "real situations."

The second objection that may be offered to our present high school physics is in measurements and units. Lord Kelvin in his "Popular Lectures" made this statement, "I often say when you can measure what you are speaking about and express it in numbers you know something about it." The average teacher of high school physics has certainly accepted this at face value. I am not sure that Kelvin ever meant this to apply to beginners. Franklin, formerly of Lehigh University, takes quite a different view. He says: "My experience is, most emphatically, that a student may measure a thing and know nothing at all about it; and I believe the present courses in elementary physics, in which quantitative laboratory work is so strongly emphasized, are altogether bad." In spite of Franklin's statement, most laboratory manuals for high school physics introduce the beginner to exact measurements to be made and recorded in new units. The student enrolls in the physics class because he is interested in electric lights, telephones, automobiles, airships, motor-boats, submarines, etc. In place of cultivating this interest—a most precious possession—we ask him to measure to the second or third decimal place the diameter of "a cylinder" with a vernier caliper or a micrometer screw. I realize measurement has its place in all courses in physics; but the whole of physics is not exact measurements. Twenty years ago it was commonly accepted that the new discoveries in physics would be found in "the sixth decimal place." Right in the face of this view came the revolutionizing discoveries of Röntgen and Becquerel, neither of which was found in "the sixth decimal place."

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Not only do we insist on exact measurements but also these measurements are to be recorded and thought of in new units. I have tried to teach beginners in physics for eleven years and I believe the one thing that has retarded my progress more than anything else is the unit situation. I am an ardent advocate of the metric system for general use; and yet I frankly confess I wish it would either come into general use or drop out entirely. I shall waste no time in arguing the superiority of the metric system when *mastered* (it is decimal, the unit of mass is logically derived from the unit of length, etc.); but it is not an easy matter to connect the work in beginning physics with the student's past experience, for he has had no experience with dynes, ergs, watts and maybe not even with centimeters. Where the metric system is taught in the grades, much of the work consists in defining the metric units in terms of the English units and then in drilling in multiplication and division by making use of such converting factors as 39.37, 15.432, etc. Some teachers have reached a point where they question the advisability of starting with metric units. The centimeter and the gram are all right; but I am convinced that such units as the dyne and the erg have no place in high school physics. Those who contend for the dyne base their argument on its use in defining the electrostatic unit quantity of electricity. If this is the only argument, we need not keep it. Try the average beginner in electricity with three systems of units and you will be as much discouraged as he is.

I shall put my third objection in the form of a question. Is not physics placed too far along in the course? The purpose of this is to allow ample mathematical preparation. To many high school teachers physics is merely problem solving. It is simply a subject in which students are expected to exercise mathematical skill. It is a case of history repeating itself in miniature, for we remember how some very noted French mathematicians about a hundred years ago, used electricity as a field in which to try out their analytical skill. Had it not been for Faraday, who could not read their mathematical language, electricity might have been added to the mathematical department. The only mathematics really needed for elementary physics is arithmetic, simple equations in algebra, and the geometry of such common figures as the triangle, parallelogram, circle, etc. What is the objection to starting the work in the tenth grade? Teachers interested in having students start

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the work earlier than the third year of the high school should read Professor Millikan's article, "Wastes in Science," published in SCHOOL SCIENCE AND MATHEMATICS, March, 1916.

Perhaps the worst objection to our high school physics is the method. We start in with *definitions* and *general statements.* What is left for the student? Let me illustrate by a recent lesson I witnessed in high school physics. Here was the experiment for the day, "Verify Hooke's law." Many teachers today question the advisability of giving Hooke's law to high school students. Were I teaching in a large high school with a class made up mostly of boys I should not hesitate to include it in the course; but not in the form as stated above. Without arguing the matter, let us decide to give it. How? Start with a concrete problem in the form of a laboratory demonstration (I say laboratory demonstration because it is probable that there will not be apparatus enough for each student to perform this experiment individually). Take a steel rod four feet long and one-third of an inch in diameter (other dimensions may be used) and fasten it in a torsion lathe; now find the weight that must be placed in the scale pan to twist the rod, say, one degree, two degrees, three degrees, etc. In like manner find the weight required to elongate a spiral spring, say, a quarter of an inch, half an inch, etc. In like manner take up the bending of a bar or rod. With these three simple demonstrations in which the students have taken a part they will easily arrive at the general statement, "The strain is proportional to the force producing it." Next we are ready for the application of this law in structural work. Now, perhaps, it is only fair to Hooke to tell the class that he enunciated this law more than two hundred years ago. A few minutes may be spent profitably on this interesting character. The relation of Hooke to his contemporaries may be touched briefly. Biography affords an elegant opportunity for vitalizing physics. Unfortunately it is too little used. By this method all laboratory values sought are needed in the solution of a definite problem. If rightly handled, the class is in the attitude of investigators. If possible, keep them in this attitude. I am not arguing for Hooke's law; there is plenty of material without it; but I believe it can be presented with profit if a method somewhat like the one briefly sketched is used.

If there has been a falling off in high school science as the Commissioner of Education says there has, it seems to me it is up to us as science teachers to find causes and remedies.

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NOTES ON BIOLOGY TEACHING.

By B. C. GRUENBERG,
Julia Richman High School, New York City.

ON FIRE AND OXIDATION.

The concern of the student of life with *fire* is taken for granted by every modern teacher of biology. The subject of oxidation lends itself particularly well to the teaching of the *experiment* as a method of inquiry.

A candle flame furnishes the most convenient fire; a large candle that will stand steadily is to be preferred to the small size.

The *flicker* of the flame suggests that burning liberates *motion* in addition to light and heat. It may well be that this motion is imposed upon the flame by air currents, as is the case with the trembling of leaves on a tree or the movement of a shirt on a clothes-line. The doubt may be resolved *by trying*—that is, by experiment. Emphasize the important fact that we have here a problem, the solution of which we shall not seek in authorities or in recourse to other people's beliefs and opinions, but in the *materials* and *forces* at hand. Have the problem formulated clearly by the pupils, that there may be no ambiguity as to just *what* we are trying to find out. The next question is, *how* shall we proceed to find out? Several methods will be suggested; a choice will be made depending in part upon materials available and in part upon the nature of the problem. It may be that two or three proposed methods are equally suitable and equally available.

Make a record or schedule of the materials used. Make a separate schedule of what is to be done with these things.

The generalized scheme for the experiment is *to shut out* air currents. A lamp chimney has the advantage that it may surround the flame on all sides and that it is transparent. Whatever method is used for shutting off the air currents stops the flickering. The result may be checked by having two candles side by side, with only one exposed to the experimental variable, that is, the-shutting-off-of-air-currents. The difference in behavior between two flames under the experimental conditions may be sufficient to satisfy the pupils with the *conclusion* that the flicker is due to outside disturbance.

If there is any disposition to discuss the matter further, be careful to remove the chimney before the flame is extinguished. It may be put on and taken off, as it were casually, several times

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before the question is closed. As the discussion nears its end, leave the chimney over the candle and the flame will expire—if the edge of the chimney fits the top of the desk closely. This will at once suggest new questions; and many of the pupils will be prepared to explain that it is the *exclusion of the air* that resulted in the dying out of the flame. But before that can be taken up, make a complete record of the first experiment, insisting upon logical sequence and clear analysis rather than upon the mechanical form of the record.

The following points should stand out clearly whatever discussions may be used.

1. *The problem:* The question to be solved.
2. *Materials and apparatus:* What was used.
3. *Operations performed:* What was done.
4. *Results:* What happened, what phenomena or changes were observed.
5. *Conclusion(s):* The answer to the question so far as it may be inferred from the *results*.

In insisting upon a correct record of the first experiment, we must shift the emphasis from the performance as an interesting "stunt," to the *argument* involved in the formulation of the problem, in the selection of materials and procedure, in selecting the significant elements from the results, and in drawing conclusions. In other words, we must establish a standard routine for *thinking* about problems. To establish the routine now is to save time later.

A second experiment, suggested by the expiration of the enclosed flame, centers on the question whether the flame *uses up* something in the air, or *gives off* something that is essential to the burning. The air being invisible, we must find some means of showing the increase or decrease in the volume of air. It may be that after several suggestions from the pupils it will devolve upon the teacher to find a feasible plan. A cylinder large enough to go over the candle and closed at one end, inserted over the lit candle standing in a dish of water, will meet all the conditions. If the former *gives off* gas (es), bubbles should be forced through the water out of the cylinder. But if the flame *uses up* part of the air, something different must happen. The possible results should be anticipated as part of the argument or mental preparation before the operation is actually performed, but with the apparatus in hand.

Some of the pupils will probably jump to the conclusion that the flame "uses up" part of the air. But we must not be too sure. It is conceivable that both processes are going on at the

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same time but at different rates. Here is a problem for the chemist—to identify the gases concerned.

When the cylinder is finally placed over the lit candle, the flame begins to "fade," it flickers a few times, and finally it expires. In the meanwhile, the level of the water inside the cylinder changes in a way that indicates a reduction in the amount of gas enclosed. We may also observe the condensation of moisture on the inside of the cylinder. We may also notice the thin column of smoke ascending from the wick. Which of all of these phenomena are significant in relation to our problem? Have pupils restate the question; this must be constantly in mind to avoid distraction by the many results or changes brought about in the course of the experimental process.

What is indicated by the change in the level of the water? Probably that something in the air has been removed by the action of the flame. By means of a ruler held alongside the cylinder, it may be possible to get an approximation of the proportion of air "used up."

But let us not overlook the possibility that something may be present in the air that was not there before. We shall have to come back to the question whether the flame gave off something. There is the smoke, for example; and perhaps there are some invisible fire-products. We may need the assistance of the chemist to answer these questions. We may be certain only, at this time, that *something has been taken from the air by the burning.*

As to the chemical nature of the remaining gas or gases, we should need some knowledge of chemistry to proceed farther. It is futile to test this air further with relation to fire—as some of the students are almost sure to suggest, and as many teachers actually do. For the failure of a flame to burn in this residual air cannot tell us anything that we did not already know. The teacher, drawing upon his fuller experience, produces a *reagent* —a substance that *reacts* distinctively with the various gases; in this case, lime water. It is just as well to explain that this is the same kind of lime water as is sometimes used in the baby's milk bottle. It is prepared by shaking up some calcium oxid (unslaked limed) with water and filtering through paper. Keep the lime water in tightly stoppered bottles; cork is better than glass but if glass stoppered bottles are used, smear a little vaseline on the stopper to make sure of an airtight joint that will not become caked.

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Place a little lime water in the bottom of glass cylinder similar to the one used in experiment. Place the palm of the hand tightly over the open end of the cylinder and shake up vigorously. Place a little lime water in the cylinder taken from over the expired flame and shake up as before. In this jar the lime water turns cloudy or milky. This shows us at least that the two masses of "air" are different, although it does not tell us just what the difference is. We may, however, conclude that the burning process not only removes something from the air but also sets free something that was not there before.

The question may here be raised as to the relation between the products of combustion and the fuel on the one hand and the materials removed from the air on the other. It is a reasonable *hypothesis* that the product, like the visible "ash" of some other fires, is either (a) some portion of the fuel thus set free; or (b) a portion of the fuel or of the air somehow "modified," or finally (c) a *new combination* of materials containing elements from the fuel, from the air, or from both.

The technique of testing these variations of the hypothesis is rather too complex for the schoolroom. We can test, however, the supposition that the product of a burning contains fuel substance plus air substance. For this purpose we must have a fuel which on burning yields a product that is easily gathered and weighed. We use magnesium ribbon—magnesium because the product of its composition is solid, and ribbon because it is convenient to handle. On one platform of a trip balance place a strip of ribbon about eight inches long and a large funnel closed with cotton wool in the stem. A wire loop or hook may be hung into the funnel before adjusting the balance. Hang the magnesium ribbon from the loop and ignite with alcohol or Bunsen flame; replace funnel immediately upon platform of the scale. If the operation has been carefully conducted, the accumulated "smoke" or "ashes" will be found to *weigh more* than the original ribbon of magnesium. Since the addition to the solid matter on scale platform could have come only *from the air*, we are tempted to conclude that the air stuff which takes part in burning combines with something in the fuel.

From these experiments the pupils may learn a great deal that is worth knowing about the relation of air to fire. It is much more important, however, that occasion be found for teaching the meaning of an experiment as an instrument for intellectual advancement. In the experiments used it is possible

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to bring out the idea that problems can be solved by concentrating phenomena under control instead of waiting to learn by "observation" of casual phenomena which come in the course of random experience. It is possible also to learn that a scientific "explanation" takes the form of an hypothesis which must be verified or tested and which is valid only so far as it fits in with experience. It is possible in the third place to learn from these experiments the idea that every question answered in a scientific way gives rise to new questions.

In general, it is well to have the materials to be used in the day's work readily accessible in the laboratory or recitation room, but *not laid out.* When you—that is the teacher *and* the pupils—decide that a lamp chimney or a funnel would be desirable, the teacher's resources must be equal to the occasion; but no matter how carefully the teacher has prepared the day's demonstration, the procedure should never give the impression of being "cut and dried" in advance. Exceptions should be made for demonstrations that involve rather elaborate arrangements or that take more time for setting up than the usual session allows. In that case, however, there is either no pretense that the experiment is performed in response to a problem which has arisen in the class; or, if you have led up to the problem, the *plans* for the experiment may be agreed upon at one session, with the understanding that the preparations will be made in anticipation of a future meeting of the class. Above all, the experiment is never to be a school substitute for a circus or a performance in magic.

LIBERTY LOAN SUBSCRIPTIONS.

Failure of rural communities to subscribe relatively as liberally as the metropolitan districts was generally ascribed not to lack of patriotism but lack of thorough organization and intensive campaigning. In future campaigns every agency will be used in the rural districts as well as in the cities. The women's organizations will be very active and hearty cooperation between them and the other organizations is assured.

Educational work in the schools of the country is to be stressed, and through the schools generally, therefore, educational campaigns are to be carried on all over the country not only during Liberty Loan campaigns but in the intervals between.

Enthusiasm, patriotism, and earnestness must be characterized in every American citizen not only at present but especially when the next Liberty Loan Campaign is on in order that the loan may be raised with the least possible effort.

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BIOLOGY IN THE HIGH SCHOOL.

By G. H. OBERTEUFFER,
High School, McMinnville, Ore.

To a biologist, a discussion of the values, aims and purposes of a high school course in biology is superfluous. Any one of its numerous values in itself would be reason enough for its incorporation in the curriculum, so great is his enthusiasm and love of his subject. But to the layman, even to the average educator, much more is needed for the justification of such a study. Let us review then the values and aims of biology and later discuss the content of our own particular course.

Herbert Spencer divides the activities of life into those concerned with self-preservation, those concerned with earning a livelihood, those concerned with the rearing of offspring, those which minister to the regulation of conduct in social and political relations, and those which minister to the gratification of our tastes and feelings. He then proceeds to prove that science more than any other study better enables us to perform these activities. In other words, if these five functions constitute our active life, and education is "the preparation for complete living," science is the most important part of our education.

But we do not want to argue that science is the *most* important part. Rather, that science, particularly biology, is a very important and a decidedly necessary part.

Science as taught today has the following abstract values: It trains the child in close observation; it develops the powers of organization, comparison and inductive reasoning; furthermore, science is a great developer of the imagination, and lastly it provides valuable information.

Biology as a science has these values. Who observes more closely than the student of nature hunting for the pupal or resting stage of the butterfly on the under side of a forest leaf? Who has keener powers of observation than the nature lover who is trying to determine the message conveyed from one little red ant to another in the antennae salute? The laboratory work in biology, leaving to the student the problem of drawing conclusions, necessitates the development and use of reasoning powers. What study can be a greater stimulus to the imagination than one which will prompt a child to say, "I'd like to be a little water beetle for a day just to see what they think about." And as to yielding valuable information, one has only to reflect that our modern study of forestry is only a branch of biology in order to

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appreciate this value. So we see that biology admirably fulfills the four greatest abstract values of science.

Before going further into a discussion of the concrete values of biology, let us gain some idea of the scope of the subject. Biology is defined as the "Science of life." Its two great subdivisions are botany and zoology. But no less are the subjects of forestry, animal husbandry, crop husbandry, agricultural technology, bacteriology, fishery and floristry, essentially divisions of biology. Physiology is purely biology, as are its allied subjects, anatomy, hygiene and sanitation. The more detailed physiological branches such as: neurology, the study of nerves; osteology, bone study; pharmacology, the study of medicines; surgery, histology, tissue study and embryology are also subdivisions of biology. Psychology is the latest biological study to gain recognition.

When we realize that any study of life or living things is biology, we have an enormous conception. And when we consider that life is simply the working out of nature's laws, biology becomes to some extent nature study, the one course from the greatest teacher of all: As Longfellow said:

And Nature, the old nurse, took
The child upon her knee
Saying, "Here is a story-book
Thy father has written for thee."

Or, in the less poetic words of the greatest adolescent psychologist, G. Stanley Hall: "To know nature and man is the sum of earthly knowledge."

Let us consider the specific values to be derived from the study of biology. In this day of commercial supremacy, perhaps it is fitting to mention the economic value first, although to me this is not the most important. A study of biology has an economic value which is of utmost importance to civilization today. What is drawing our nation into the present European conflict? Germany's attempt to prevent her enemies from obtaining food, the production of which is economic biology. What will eventually defeat Germany? Starvation! The prevention of which is also economic biology. The United States owes its martial immunity today to the fact that it is self-supporting. Our government bureaus of agriculture, forestry and sanitation are biological institutions. Our manufacturing and commerce have attained a wonderful growth, but they are based upon our agriculture, which is in turn nothing but the working out of nature's laws.

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Such vital subjects as pure air, pure water, bread making, shade trees, forest conservation, disease prevention, game birds, fungus and bacterial growths and weeds are studied in economic biology. In one year the cost of our entire school system in the United States is 285 million dollars, while the crop destruction by insects is 300 million. When we ponder such figures as these, the economic value of biology is clearly seen.

The aesthetic value is also great. The love of the beautiful forms a large part in the life of us all. Flower culture is an evidence of an instinctive love for beauty. This love is as old as man himself and was expressed in flower culture by the ancients. The beautiful hanging gardens of Babylon in 680 B. C. furnish us an example from history.

Where outside of nature do we find anything as beautiful as a violet? What man-made shade of yellow rivals the daffodil? And even the commonly despised pond scum, when placed under the microscope shows a wonderful spiral arrangement of glistening emerald bonds.

"Consider the lilies of the field, how they grow: they toil not, neither do they spin, and yet I say unto you that even Solomon in all his glory was not arrayed like one of these."

Much of our literature and poetry has for its theme, nature. The works of Bryant, Wordsworth, Longfellow, Tennyson, Lowell, Whittier, Helen Hunt Jackson, Lucy Larcom, Burroughs, and Thoreau will prove this.

Biology has an ethical and social value, in that the knowledge obtained therein helps a child in the determination of what is right and wrong. No student of biology maliciously robs a bird's nest or is guilty of cruelty to animals. Animal study awakens a sympathetic interest and love for all animal life and creates a realization not only of the brotherhood of man but of the broader brotherhood of all animals. The shade trees, beautiful lawns, floral displays, porch boxes and botanical gardens in any community are the result of the social value of biology. The pride in the outside appearance of one's home is a value not to be neglected. Caring for gardens and animal pets teaches the child habits of industry, carefulness and unselfishness.

To illustrate further the social value, consider the lessons we may draw from the ant colony. The type of civilization found among the ants in some respects surpasses human civilization. The ant community is the very personification of industry. There are no lazy ants. They are born to work and each indi-

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vidual performs his task day after day with no bosses or overseers, nor any compensation for his work other than the aid rendered to the colony. The division of labor is remarkable; certain members of the group are specialized as workers, others as warriors, sentinels, burden bearers, engineers, nurses, but no lawyers, jailors, legislators, administrators or doctors. In an ant colony the morality is so good that policemen and jails are unnecessary. Law makers are of no avail because ants do not break nature's laws. And doctors are superfluous when we consider the physical development of the individuals. A man with the proportionate strength of an ant could bear a ton of coal upon his back. This enormous strength is best shown by the ant engineers. When the colony is on the march these are in the advance guard and when a stream is reached they make a living bridge across it with their bodies and remain suspended so for hours, while thousands of their comrades march across on their backs. Then when the last members are over, the engineers hurry to the front ranks to repeat the service at the next stream. Another virtue of the tiny ant is patriotism. Not one ant in the whole colony hesitates to fight and die if necessary in the defense of his home.

Thus biology has an economic, aesthetic, ethical and social, and religious value. Does any other subject have such a diversity? Froebel conceded to nature study the honor of saving education from becoming hollow, empty and artificial. And when we realize that nature has built up the human brain to its present level and then try to conceive of a plan of education that leaves nature in the background, we are quite apt to be laying frail foundation for the building of intelligent human character.

Our own course has been organized on a basis of emphasizing an aesthetic appreciation of the wonders and beauties of nature. Admitted this is not practical, and cannot be turned into money, yet we have other departments well organized and equipped to tend to this need. But in no course, with the exception of art and possible literature, have we an equal opportunity of creating this aesthetic love and appreciation of the beautiful and wonderful. The child today is apt to so overdevelop in the practical, money making and livelihood obtaining lines that his future will be a sordid, mechanical existence, devoid of anything but artificial pleasure. Not that we criticize the industrial, commercial or any other department of work; all are necessary if education fits a child for complete living.

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Secondly, we attempt to develop powers of thinking, reasoning and observation. Our laboratory work and field trips minister to this end. The economic and socializing values are of next importance to us in our teaching. The religious value would be spoiled if we attempted to teach it. But from time to time as we study and investigate, this great truth comes to the child as an inspiring realization.

A very brief outline of the content of our course is as follows:

1. A series of elementary, introductory discussions on the purpose and scope of biology, elements of physics and chemistry to explain environment, composition of material, etc. The aim is to arouse interest and give the student the tools with which he will later work.

2. A study of the flower; roots, stem and leaves.

3. Photosynthesis (starch-making in the leaf) as the elementary food factory of the world.

4. Pollination, as the mutual help of nature's forces.

5. Fertilization and germination as part of nature's plan.

6. The entire plant kingdom; a study of type forms, to show variation and diversification.

7. A study of plant reproduction from simple fission to pollen and ovule union or fertilization, to illuminate the function of reproduction in a new and proper light.

8. The relation and interdependence of plants and animals, including the similarities of the microscopic organisms.

9. The detailed study of animals from the most lowly one-celled forms up to man, from the standpoint of the nine vital functions common to all animals: food-taking, digestion, sense organs, locomotion, excretion, respiration, nervous control, reproduction and circulation.

This study shows clearly the universal brotherhood of all animals and contributes to all of the aims of biology. Incidentally, it solves the problem of sex instruction in the high school in such a clean and indirect, yet efficient and unoffensive way that there is no need for any additional instruction. The student realizes that it is a necessary God-given function, common to all forms of life on earth.

The entire year's work is supplemented by laboratory experiments with real material, organized on the plan of letting the student do the work and discover the facts. Field trips are an integral part of the instruction and are made inspirational and instructive.

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A FRIENDLY NOTE ON DR. HILTON JONES' ARTICLE.

Dear Mr. Smith:

I am so acutely aware of my own unimportance that I hesitate to ask if you will permit the use of SCHOOL SCIENCE AND MATHEMATICS for a very friendly answer to certain remarks of Dr. Jones in his worthy article found in SCHOOL SCIENCE AND MATHEMATICS for January, 1918. The fact that you have before this permitted certain of my articles to appear there is the only reason why this particular lamb dares to roar back at the lion.

I am Eastern by birth, training and desire. The West, especially South Dakota, has always appeared too drafty for me.

Genius is impetuous. Nothing is impossible for genius to imagine; not even the securing of men with specialized graduate work to take poorly paid positions far from the soothing influences of the symphonies, libraries and jazz bands of the "bean eating," "effete" East.

As Doctor Jones states, there is a vast difference between teaching science to high school students "to make scientists" out of them—although the majority of them will never use articles more scientific than a vacuum cleaner, nor make demands on their chemistry more than to see whether the water is hard or soft by the soap test—and teaching so that snobbish tendencies toward a foolish culture aim are immediately apparent.

I doubt if the West as a whole intends to make scientists of all high school students, even as it comes to me as a surprise that the "effete," "bean eating" East sees in the modern sciences only a chance for cultural development.

This lamb roars from a well equipped laboratory and holds his tiny sheepskin—proving graduate work—as fitting him to speak at all, modestly in front of him. Someone had to come to the rescue, or I am certain that many Eastern readers would always have a feeling of absolute humiliation and sorrow for their condition after reading the second sentence of the third paragraph from the end, or limit of Dr. Jones' article.

Sincerely,

H. L. CHASE,
Stevens High School, Claremont, N. H.

FORESTRY EXHIBITS AND SLIDES LOANED BY THE GOVERNMENT.

Traveling exhibits of woods, of charts, maps, and diagrams concerning forest products and of photographs on forest subjects and sets of colored lantern slides, accompanied by lecture outlines, relating to trees and forests are loaned by the Forest Service of the U. S. Department of Agriculture, Washington, D. C., free of charge except for transportation. The wood exhibits consist of sixty-four samples of commercially important woods of the United States, maps showing the region in which each species grows, short statements of their principal uses and physical characteristics, charts and tables showing forest products by states, the rise and fall of the lumber industry, and the percentage of lumber supplied by different regions, and maps of the natural forest regions of North America and the national forests.

The photograph exhibits contain forty-four or forty-eight large mounted photographs of forests of the United States, their use and preservation, and the administration and use of the national forests. These photographs are arranged in series, which form illustrated stories.

Both wood and photograph exhibits are placed on mounts measuring 16½ inches by 10 inches, which are arranged on panels, containing four

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mounts each. In the upper corners of each panel are eyelets for hanging. One entire exhibit covers a wall space about 4½ feet high and 14 feet long.

Sets of colored lantern slides of fifty or more slides each are available on the following subjects:

"Forestry in the United States."
"Work of the Forest Service."
"The Farm Woodlot" (for Eastern States).
"Tree Windbreaks" (for States of the Central and Middle-South Regions).
"Nature Study and Forestry."
"Botany and Forestry."
"Manual Training and Forestry."
"Geography and Forestry."
"Agriculture and Forestry."

A syllabus for a lecture accompanies each set.

Slides are loaned for short periods, usually of one or two weeks, and the exhibits for three weeks to schools, clubs, lecturers, and others engaged in educational work, on condition that the borrowers pay transportation charges, be responsible for the material while charged to them, and forward it promptly at the direction of the Forest Service. Effort is made to arrange itineraries of exhibits so that borrowers will usually have to pay transportation only one way, and whenever practicable transfers are made between borrowers residing near each other. Ordinarily these arrangements are impracticable for lantern slides, and their transportation from Washington and return is paid by each borrower. The lantern slide sets, packed for shipment, weigh usually less than fifteen pounds, the exhibits less than twenty-five pounds.

Applications for these materials should be made to the Forest Service, Washington, D. C. Applicants should state that they agree to the conditions on which loans are made, as outlined above.

A PROBLEM IN REGULAR POLYGONS.

By M. H. Pearson,

Montgomery, Ala.

Certain books in mechanical drawing give the following method for inscribing a regular n-gon in a circle, but fail to admit that, except for special cases, it only approaches accuracy.

On the diameter AB construct the equilateral triangle ABC. Divide the radius AB into n equal parts. Measure off BD on BO equal to 4 equal parts. Draw CD to cut the farthest side of the circle at E. Then BE is the proposed side of the n-gon.

Now, the equation of the circle of radius r, referred to OC and OB as axes of coordinates, and the equation of the line CE are, respectively,

$$x^2+y^2 = r^2, \tag{1}$$

and

$$(n-4)x+ny\sqrt{3} = r(n-4)\sqrt{3}. \tag{2}$$

We see that

$$\overline{BE}^2 = x^2+(r-y)^2 = 2r^2-2ry. \tag{3}$$

Solving (1) and (2) for y, and substituting in (3), we have, after simplifying,

$$\overline{BE}^2 = \frac{r^2(n^2+4n+16\pm\sqrt{n^4+8n^3-144n^2+512n-512})}{2(n^2-2n+4)}. \tag{4}$$

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For $n = 3, 4, 5, 6, 8, 10, 12$, the values of $\overline{BE}^2$ in (4) are, respectively $3r^2, 2r^2, r^2/38(61-\sqrt{73}), r^2, r^2/13(14-2\sqrt{10})$, $r^2/84(78-11\sqrt{17})$, and $r^2/31(26-4\sqrt{29})$.

As will be seen, we use the positive sign of the radical in (4) for $n = 3$, either sign for $n = 4$, and the negative for n greater than 4. That is because E is below the x-axis, on the x-axis, or above it, according as n is 3, 4, or greater than 4.

Incidentally, the radical is imaginary for $n = 1$ or 2.

These results for $n = 3, 4, 6$, are the squares of the well-known values of the sides of the regular triangle, square, and hexagon. The other results are only close approximations.

PROOF OF GEOMETRICAL THEOREM.

By TAKESHI OMACHI,

In Sendai, Japan.

Another proof of the theorem that in any triangle, the product of two sides is equal to the product of the segments of the third side formed by the bisector of the opposite angle plus the square of the bisector.

Let AD bisect the angle A of the triangle ABC, cutting BC at D; then,

$$AB \times AC = DB \times DC + \overline{AD}^2$$

Produce BA to E, making AE = AC, and join CE. Let a parallel through A to BC meet CE in F, then we have DC = AF, AD = FC. The triangles ABD, EBC are similar, and give,

$$\frac{AB}{BE} = \frac{BD}{BC} = \frac{AD}{EC},$$

$$\text{whence } \frac{AB}{BE-AB} = \frac{BD}{BC-BD} = \frac{AD}{EC-AD},$$

$$\text{or } \frac{AB}{AC} = \frac{BD}{DC} = \frac{AD}{EF},$$

$$\text{hence } \frac{AB \times AC}{\overline{AC}^2} = \frac{BD \times DC}{\overline{DC}^2} = \frac{\overline{AD}^2}{EF \times AD},$$

$$= \frac{BD \times DC + \overline{AD}^2}{\overline{DC}^2 + EF \times AD}.$$

Since the triangle ACE is an isosceles triangle,

we have $\overline{AC}^2 = \overline{AF}^2 + EF \times FC$,

therefore $\overline{AB}^2 = BD \times DC + \overline{AD}^2$.

WANTED.

Thirty-five cents will be paid for unmutilated copies of the October 1911 issue of this Journal. Send to the Business Manager.

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PROBLEM DEPARTMENT,

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2501 W. 110th Place, Chicago.*

546. *Proposed by W. W. Gorsline, Crane Technical High School and Junior College, Chicago.*

The following six groups of numbers A, B, C, D, E, F, comprise a well known game or "puzzle." Any number less than 64 is selected and the groups in which it occurs are denoted, e. g. 37 : in A, C and F. By adding the first numbers in the respective groups the number is determined as $1+4+32=37$. Find the secret of arrangement of numbers and possibly derive a formula of arrangement for n groups.

A

1	3	5	7	9	11	13	15
17	19	21	23	25	27	29	31
33	35	37	39	41	43	45	47
49	51	53	55	57	59	61	63

B

2	3	6	7	10	11	14	15
18	19	22	23	26	27	30	31
34	35	38	39	42	43	46	47
50	51	54	55	58	59	62	63

C

4	5	6	7	12	13	14	15
20	21	22	23	28	29	30	31
36	37	38	39	44	45	46	47
52	53	54	55	60	61	62	63

D

8	9	10	11	12	13	14	15
24	25	26	27	28	29	30	31
40	41	42	43	44	45	46	47
56	57	58	59	60	61	62	63

E

16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

F

32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

I. Solution by R. M. Mathews, Riverside (Cal.) Polytechnic High School.

In Vol. XIII, p. 119 (December, 1913), of this journal I published a note on these "Magic Number Cards," showing their secret and how to make them for other sets.

The key number on each card is a power of 2, the powers ranging from 2^0 to 2^5. Determine the powers of 2 whose sum equals a given number and place it on each card of the power involved. Thus, $37 = 2^5+2^2+2^0$.

If n be chosen as a base, represent the given number on the scale of n and mark it on each card of the power involved. However, a card will be needed not only for each power of n but also for 2, 3, 4, . . . $(n-1)$ times each power. Thus with base 5 we have $13 = 2 \cdot 5^1+3 \cdot 5^0$ and 13 is marked on the cards with "key number" $10 = 2 \cdot 5^1$ and on $3 = 3 \cdot 5^0$.

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II. Solution by E. B. Escott, care of Kansas City Life Insurance Co.

The numbers at the corners are the successive powers of 2. Therefore, if the different numbers of the natural series 1, 2, 3, . . . are expressed as the sum of powers of 2, these will show in which tables they will appear. In other words, express the natural series in the binary scale.

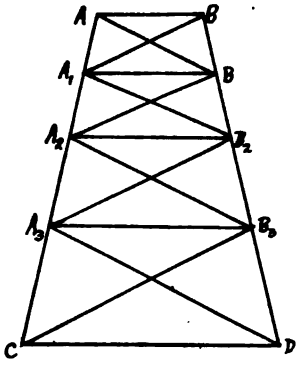
Decimal Scale.	Binary Scale. EDCBA	
1	1	Column A contains alternate 1's and zeros. Wherever a 1 occurs, the corresponding number in the decimal scale occurs in Table A. We see that only the odd numbers occur in this table. Likewise, from Column B, we see that Table B contains two consecutive numbers of the natural system, then two are omitted, etc. From Column C, we see that Table C contains four consecutive numbers of the natural system, commencing with 4, then the next four are omitted, etc.
2	10	
3	11	
4	100	
5	101	
6	110	
7	111	
8	1000	
9	1001	
10	1010	
11	1011	
12	1100	
13	1101	
14	1110	
15	1111	
16	10000	
.	.	
.	.	

Solutions to this problem were also received from ISIDORE GINSBURG, C. E. GITHENS.

547. *Proposed by Norman Anning France.*

The cap and sill of a high trestle bent are respectively 150 and 400 inches long. Find the lengths of three intermediate caps which are so spaced that the diagonal braces are parallel from top to bottom.

Solution by the editor.



$AB = 150$, $CD = 400$;
$AB_1 \parallel A_1B_2 \parallel A_2B_3 \parallel A_3D$;
$A_1B \parallel A_2B_1 \parallel A_3B_2 \parallel CB_3$,

Let $A_1B_1 = l$, $A_2B_2 = m$, $A_3B_3 = n$.

Triangles AA_1B_1, $A_1A_2B_2$, ... are similar.

Triangles AA_1B, $A_1A_2B_1$, ... are similar.

$$\therefore \frac{150}{l} = \frac{AA_1}{A_1A_2} = \frac{l}{m} = \frac{A_1A_2}{A_2A_3} = \frac{m}{n} = \frac{A_2A_3}{A_3C} = \frac{n}{400}.$$

Let $1/r$ represent this ratio. Then $l = 150r$, $m = rl$, $n = rm$, $400 = rn$, whence

$150r^4 = 400$, and $r = \sqrt[4]{8/3} = \frac{1}{3}\sqrt[4]{216}$.

$\therefore l = 191.68$, $m = 244.95$, $n = 313.02$.

Geometry.

548. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Three points A, B, and C start from S on the circumference of a circle to move around the circumference at uniform rates, a, b, and c, respectively. If length of the circumference is P and $c > b > a$ find the condition

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that the first time they are together again shall be at S; also the time that is required for them to meet again at S.

Solution by the Editor.

Consider the second part first.

Let a, b, and c represent integral rates in units of distance per unit of time of A, B, and C, respectively (which assumes they are mutually commensurable). Let P represent units of distance in the circumference. Then P/a, P/b, P/c represent the time of one complete revolution for A, B, C, respectively. The shortest time required to meet again at S is L. C. M. of P/a, P/b, P/c which is P/d, where d is the G. C. D. of a, b, c. For, the L. C. M. of several fractions is the L. C. M. of their numerators divided by the G. C. D. of their denominators. (If $d = 1$ the time is P.)

Concerning the first part, we will prove the following:

Necessary and sufficient conditions that A, B, C, are together again before meeting at S are

$$b = a+ks, \qquad (1)$$

$$c = a+ls,$$

where k, l, s are positive integers and where s is not an integral factor of a. (According to the problem, of course $l > k$.)

Assume, for simplicity, that a, b, c have no common factor.

Let T be a point of meeting before coming together at S and let arc $ST = rP/s$, r and s prime to each other. Represent the number of revolutions for A, B, C, respectively, from the start until meeting at T by $u+r/s$, $v+r/s$, $w+r/s$. (u, v, w positive integers.)

Since P/a, P/b, P/c represent the time for each revolution of A, B, C, respectively, then

$$P(u+r/s)/a = P(v+r/s)/b = P(w+r/s)/c, \qquad (2)$$

whence

$$av-bu = \frac{(b-a)r}{s}.$$

Since $av-bu$ is integral, $b-a$ is a multiple of s. Similarly, $c-a$ is a multiple of s and we have equations (1) as a necessary condition that the meeting point be at some point T before the points come together at S.

Conversely, if we assume equations (1), then

$$P/a,\ P/(a+ks),\ P/(a+ls)$$

represent the time of one revolution for A, B, C, respectively; P represents time elapsed from the start until they are together at S; and a, $a+ks$, $a+ls$ represent the number of revolutions until together at S. If the number of revolutions for each be divided by s, the numbers a/s, $a/s+k$, $a/s+l$ thus obtained represent each a number (not integral) of revolutions such that the points A, B, and C, would be together at a point T where arc $ST = a/sP$.

Illustration:

Let $a = 7$, $b = 11$, $c = 17$ ($s = 2$, $k = 2$, $l = 3$) and let $P = 100$, say. To meet at S again A makes 7, B 11, C 17 revolutions in 100 units of time. They also meet in 50 units of time at a point T opposite S, A having made 3 1/2, B 5 1/2, C 8 1/2 revolutions.

Note: The argument is the same if a, b, c have a common factor, the notation merely being encumbered with an extra symbol.

549. *Proposed by Murray J. Leventhal, New York City.*

Given an equilateral triangle ABC and point P, so that $PA = PB+PC$. Show that the locus of P is a circle. (From a New York City examination for teachers.)

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Solution by Nelson L. Roray, Metuchen, N. J.

Take the circumcircle of the triangle and let P be any point on the arc BC. Through C take a parallel with PB intersecting AP at M.

Then $\triangle MPC$ is equilateral and PM = PC. Also $\triangle AMC = \triangle BPC$ and AM = BP.

$\therefore$ AP = PB + PC.

Take P′ any point outside the circle on AP.

Then in $\triangle BP'C$

$$P'C^2 = PP'^2 + PC^2 + PP' \cdot PC,$$
$$P'B^2 = PP'^2 + PB^2 + PP' \cdot PB,$$

and

$$P'C^2 - P'B^2 = PC^2 - PB^2 + PP'(PC - PB),$$

or

$$\frac{P'C + P'B}{PC + PB + PP'} = \frac{PC - PB}{P'C - P'B}.$$

Since $\angle BPA = \angle APC = 60°$, $PC - PB > P'C - P'B$,

$$\therefore P'C + P'B > PC + PB + PP'$$
$$> PA.$$

Similarly for any point on PA between A and P.

$\therefore$ The locus of P is the circumcircle of ABC, provided the algebraic sum is understood for PB + PC, due regard being observed for the signs of PB and PC.

A second solution was received from NELSON L. RORAY, *and one from* R. M. MATHEWS.—*Ed.*

550. *Proposed by Daniel Kreth, Wellman, Ia.*

Given the altitude and radii of the circumscribed and inscribed circles of a plane scalene triangle, to construct it and determine its sides.

Solution by Nelson L. Roray, Metuchen, N. J.

Let r, R, h and c be the radius of the in-circle, circumcircle and altitude upon the side c respectively of the triangle.

Then we have at once

$$c = \frac{h \sin(A+B)}{\sin A \sin B} \tag{1}$$

$$c = \frac{r \sin \tfrac{1}{2}(A+B)}{\sin \tfrac{1}{2}A \sin \tfrac{1}{2}B} \tag{2}$$

$$c = 2R \sin(A+B) \tag{3}$$

From (1) and (2) we readily obtain

$$\frac{h-2r}{h} = \tan\frac{A}{2}\tan\frac{B}{2}. \tag{4}$$

and

$$\frac{2r}{h}\cos\frac{A}{2}\cos\frac{B}{2} = \cos\tfrac{1}{2}(A+B).$$

$$\frac{c}{r}\sin\frac{A}{2}\sin\frac{B}{2} = \sin\tfrac{1}{2}(A+B). \qquad \text{[From (2)]}$$

whence

$$\frac{4r^2}{h^2} + \frac{c^2}{r^2}\left(\frac{h-2r}{h}\right)^2 = \frac{1}{\cos^2 A/2 \cos^2 B/2} \tag{5}$$

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$$\tan A/2 \tan B/2 = \frac{h}{8R}\left(\frac{1}{\cos^2 A/2 \cos^2 B/2}\right) \qquad (6)$$

From (4), (5) and (6)

$$\frac{4r^2}{h^2}+\frac{c^2}{r^2}\left(\frac{h-2r}{h}\right)^2 = \frac{8R(h-2r)}{h^2}$$

whence

$$c = \frac{2r}{h-2r}\sqrt{2Rh-(4Rr+r^2)}$$

This determines c in terms of r, R, and h and the triangle is easily constructed.

Using (1) and (3) and the well known formula

$$r(\sin A+\sin B+\sin C) = 2R\sin A\sin B\sin C$$

we easily obtain

$$\sin B = \frac{c(h-r)\pm\sqrt{c^2(h-r)^2-8Rr^2h}}{4Rr}$$

$$\sin A = \frac{c(h-r)\mp\sqrt{c^2(h-r)^2-8Rr^2h}}{4Rr}$$

whence by Law of Sines

$$b = \frac{c(h-r)\pm\sqrt{c^2(h-r)^2-8Rhr^2}}{2r}$$

$$a = \frac{c(h-r)\mp\sqrt{c^2(h-r)^2-8Rhr^2}}{2r}$$

Note: *A solution to 536 was received from* NELSON L. RORAY *too late for publication.—Ed.*

PROBLEMS FOR SOLUTION.

Algebra.

561. *Proposed by the Editor.*
Factor

$$x^3y+x^3z+xy^3+xz^3+yz^3+y^3z+2xyz.$$

562. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

If n is a prime number, show that $\lfloor n-1+1$ is a multiple of n.

Geometry.

563. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Using the figure for the Theorem of Pythagoras as given on page 194 of Wentworth's *Plane Geometry* (Edition of 1899), prove

(1) BK, AL and FC are concurrent.

(2) Let X be the intersection of FC and AB, then GX, AD and BC are concurrent.

Prove by means of theorems that are usually given in Book I of plane geometry.

564. *Proposed by N. P. Pandya, Sojitra, B. B. and C. I. Ry., India.*

ABC is a triangle, right-angled at A. AP, AQ are squares on AC, AB, respectively. PB cuts AC at D. QC cuts AB at E. Show that DE is parallel to PQ.

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565. *Proposed by L. E. Lunn, Heron Lake, Minn.*

Prove that the lines joining the vertices of a tetrahedron to the centers of the opposite faces are concurrent at the centeroid of the tetrahedron and are quadrisected at this point. Use only elementary geometry.

SCIENCE QUESTIONS.

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Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Science Tests.

To those who have asked to be enrolled as cooperating on science tests some lists in physics have already been mailed. Chemistry will follow. Suggestions are desired. Returns will be compiled as rapidly as received and communicated to all as quickly as possible.

Additional names received too late for insertion in the March issue: Ira C. Davis, Wisconsin High School, Madison, Wis.; Lynn B. McMullen, State Normal School, Valley City, N. Dak.; Theo. S. Rowland, North East High School, Philadelphia, Pa., H. E. Hammond, Kalamazoo, Mich., Charles J. Pieper and E. L. Harrington, Univ. High School, Chicago, W. A. Hedrick, Central High School, Washington, D. C.

QUESTIONS AND PROBLEMS FOR SOLUTION.

298. *Proposed by G. R. Robertson, Riverside, Cal.*

Why does ammonium hydroxide—a weak, poorly ionized base—attack glass bottles, and what does it do to the glass?

299. *Proposed by O. L. Brauer, Selma, Cal.*

Would the specific heat of a metallic container have any influence on the rate at which it would radiate heat from water within it?

300. *Proposed by J. C. Packard, Brookline, Mass.*

In apartment houses with separate meters, do the people on the top floor get more or less gas for their money? Discuss quantitatively.

301. *Proposed by C. H. Prescott, University School, Cleveland.*

How many calories of heat must be supplied to melt 10 grams of ice?

Is the answer the same when British Thermal Units (B. T. U.) are used? Explain.

Examination Papers.

The receipt of examination papers is gratefully acknowledged from C. T. Beach, Tunkhannock, Pa.; Annie Cloyd, Sewickley, Pa.; R. A. Montgomery, Cushing Academy, Ashburnham, Mass.; H. K. Rhodes, Chambersburg, Pa.; W. F. Roecker, Boys Tech. H. S., Milwaukee, Wis.; W. A. Zinzow, Wausau, Wis.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Send your first term examination now.** If a representative number of papers in physics, chemistry and other sciences can be obtained, the Editor will attempt a comparison of school with college entrance examinations.

Correspondents say they use questions from the papers here published freely in their own examinations. **Do your share now** by slipping *any* (do not wait for all) of your old examination papers into an envelope addressed to Franklin T. Jones, University School, Cleveland, Ohio. Many will be published.

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Biology—December, 1917, Cushing Academy.

Submitted by R. A. Montgomery, Ashburnham, Mass.

I. Define: Zoology, Fertilization, Cell, Leucocytes, Celia, Pericardium, Parasite, Carnivorous, Assimilation.

II. a. Name the different food substances for plant and animal life and give illustration of each.
b. How can you differentiate between living and lifeless things?

III. a. Explain the difference between photo-synthesis and respiration in plants.
b. Name the different parts of a flower.
c. Name the different parts of a typical leaf.
d. Discuss the different methods of pollination.

IV. Locate and state function: Senticel; root cap; ocellus; carotid artery; spiracles; proboscis; ovary; gall bladder; ovipositor; air bladder.

V. Trace the complete circulation of the blood of a frog.

VI. a. Name all external appendages of a fish and compare where possible with the same in a frog.
b. Discuss the life history of a frog from egg to adult.

VII. Discuss the methods of protection: frog, moth, grasshopper, bee, lobster. Discuss honey bees.

VIII. State economic importance of the following: ichneuman fly, lady bug, ants, ground beetles, mosquitos, gypsy moth, Buffalo gnats, Hessian fly, chinch bug, bollweevil.

IX. a. Discuss metamorphosis.
b. Give complete life history of the butterfly.

X. a. Name the different divisions of the thorax of a grasshopper and appendages of each.
b. Discuss protozoa.

General Science—1st Semester, 1918, Chambersburg High School.

Submitted by H. K. Rhodes, Chambersburg, Pa.

(Answer any eight.)

1. Name some bodies composed of copper; paper; stone; iron; rubber. Which of these are organic? Inorganic?

2. A tank is 1 m. deep, 1.5 m. long, 7.5 m. wide. Find its contents in cubic meters.

3. In the laboratory we have two bottles exactly the same in size and capacity; yet one will hold 9 lbs. of sulphuric acid, the other will hold 7 lbs. of nitric acid. Explain this.

4. What are the boiling and freezing points on the C & F scales? Room temperature? Explain why pure acetic acid freezes at 16° C.

5. Name the simple machines. Why are they called machines?

6. Show by a diagram how a double concave lens can remedy near-sightedness.

7. Show by diagram the path of light through a simple periscope. What is the purpose of the periscope?

8. Name two things which are transparent; two which are translucent; two which are opaque. How can the intensity of a light be measured?

9. Write a paragraph on "The Weather Bureau"—what it does, instruments used, maps, etc.

10. Make a diagram of a siphon. Explain fully the use and action of a siphon.

SOLUTIONS AND ANSWERS.

286. *Proposed by John C. Packard, Brookline, Mass.*

Why does the image in a plane mirror, held parallel to the object, appear reversed but not inverted?

Answered by Annie Cloyd, Sewickley, Pa.; R. E. Dooley, Elmer, Okla.; Tracey F. Tyler, Wood River, Neb.; L. E. Lunn, Heron Lake, Minn.; J. E. Running, Ottawa, Ill.

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Answer by R. E. Dooley, Elmer, Okla.

The apparent reversal but not inversion is due neither to the mirror nor any peculiarity of the object, but to our use and understanding of the words "right," "left," "top," "bottom." The following experiment will make the entire matter clear. Put a glove on the left hand (solely for concreteness), call that hand "top" and the right hand "bottom," then call the feet "left" and the head "right." Stand with outstretched arms before a plane mirror and the image will appear "inverted" but not reversed. The illusion is solely in the terms used.

Answer by J. E. Running, Pleasant View Luther College, Ottawa, Ill.

Suppose a person stands facing you. With respect to your own, his position is in reality reversed; that is, his left is towards your right, and his face is turned in the same direction as your back. If this person is now commanded to "about face" his right will be towards your right and his face turned in the same direction as your face. Suppose now that all but his very front surface became invisible, you would then see his front surface facing away from you, but to you he would appear to be turned towards you because your experience has taught that you can see a person's front only when it is turned towards you. Your image in the mirror is that of your front surface facing in the same direction as you are facing and with the rest of the body eliminated. Consequently, your image is not reversed as it appears.

289. *From an examination paper of Anglo-Chinese College.*

If a burner can heat 2 kg. of water from 10° to 80°C. in 10 minutes how much water can it boil away into steam in one hour?

Solved by Annie Cloyd, L. E. Lunn.

Solution by Annie Cloyd, Sewickley, Pa.

Heat necessary to vaporize 1 gm. of water = 536 cal.; to vaporize 1 kgm. of water, 536,000 cal.

Burner gives heat at rate of $2000 \times 70 \div 10 = 14{,}000$ calories per min.

In 60 min. $60 \times 14{,}000 = 840{,}000$ cal.

$840{,}000 \div 536{,}000 = 1.567$ kgm. of water would be vaporized.

290. *From an examination paper of Boston University.*

If 2 gm. of potassium chloride yield 3.84 gm. of silver chloride, what is the atomic weight of potassium?

(Note.—At. wts.: Hg = 200.5, Ag = 108, Cl = 35.5.)

Solution by Annie Cloyd.

$$\begin{array}{lcl} KCl + AgNO_3 & \longrightarrow & AgCl + KNO_3 \\ x + 35.5 & & 108 + 35.5 \\ 2\text{gm.} & & 143.5 \\ & & 3.48\text{ gm.} \end{array}$$

$$\frac{x + 35.5}{2} = \frac{143.5}{3.48}$$

$x = 39.2$ atomic weight of potassium.

294. *From "An Elementary Study of Chemistry," by McPherson and Henderson (Ginn & Company, 1917).*

The heat evolved in the slacking of 100 kg. of lime would raise the temperature of what weight of water from room temperature (say 18°) to boiling?

Solved by Joseph Rokke, Alexandria, Minn, and S. F. Davis.

Solution by S. F. Davis, John Tarleton Ag. Col., Stephanville, Tex.

$CaO + H_2O = Ca(OH)_2 + 15{,}540$ cal.

In other words, one gram molecular weight (56 gms.) of CaO will produce 15,540 calories of heat.

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$\frac{15,540}{56}$ = 277.5 cal. produced from the slacking of one gram.

$277.5 \times 1000 \times 100$ = 27,750,000 cal. from 100 kg.

$100° - 18°$ = 82° temperature interval through which the water would be raised.

$\frac{27,750,000}{82}$ = 338,414 grams of water which would be raised from 18° to boiling.

THE PRESIDENT'S DEFINITION OF GERMANISM.

Innumerable articles and many books have been written to define "Germanism" and show to the world what it means.

In his message to Congress, December 4, President Wilson defines it as follows:

"This intolerable Thing of which the masters of Germany have shown us the ugly face, this menace of combined intrigue and force which we now see so clearly as the German power, a Thing without conscience or honor or capacity for covenanted peace."

This Thing must be crushed, and if not truly brought to an end, at least shut out from the friendly intercourse of the nations, says the President, and it is only when this Thing and its power are indeed defeated that the time can come when we can discuss peace with the German people.

MEETING OF THE ASSOCIATION OF TEACHERS OF SECONDARY MATHEMATICS OF NORTH CAROLINA.

This meeting was held at Greensboro, February 1 and 2. A popular lecture on "The Origin of Mathematics," a somewhat more technical one on "Deficiencies in Present Preparatory Mathematics," and a round table discussion on the topic "A Proper Approach to Elementary Mathematics" were the contributions of the chief speaker, Dr. David E. Smith. Papers were presented to the Association by Miss Fannie Starr Mitchell, of the Raleigh High School, Mr. J. W. Lasley, Jr., of the University of North Carolina, Miss Virginia Ragsdale, of the Normal College, and Miss Ella Bradley, of the Gastonia High School.

The following officers were elected: Mr. W. W. Rankin, Jr., of the University of North Carolina, President; Mr. S. L. Sheep, of the Marion High School, First Vice-President; Miss Maria Graham, of the Eastern Carolina Training School, Second Vice-President; Miss Nita Gressitt of the Greensboro High School, Third Vice-President; Mr. J. W. Lasley, Jr., Secretary.

The Mathematics Club of the University of North Carolina held an informal smoker on the night of Wednesday, February 6. A paper on "A Method for Finding the Complex Roots of a Cubic Equation" was presented to the club by Mr. J. W. Lasley, Jr., of the department of mathematics. A noteworthy feature of this meeting of the club was the presence of certain of the best men in the freshman class. To interest these men at the outset of their college career and to get into a closer touch with them than the classroom affords are among the aims of the organization.

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These national periodicals are printed in the big cities—and the first zone, the cheapest zone, is in or near those cities; there are many educational opportunities near cities, and the cities will read anyway. Small towns and distant districts depend to a large extent upon periodicals; thus this law increasing postage where it is most needed shuts off opportunity where needed. It penalizes periodical readers.

Repeal this law. Repeal this FIFTY TO NINE HUNDRED PER CENT periodical postage increase. Sign the petition below and mail it. Put a cross mark in the square—save the periodicals and the work that they have done and are doing for national education and patriotism.

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The postal amendment passed by the last Congress increasing the postage on periodicals from FIFTY TO NINE HUNDRED PER CENT will throttle or destroy our periodicals at a time when the widest and most extensive circulation of publications is essential to the patriotism, education, and upbuilding of our country.

Therefore, I the undersigned, do most earnestly demand the repeal of this burdensome periodical postage amendment.

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NATIONAL FORESTS MUCH USED.

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There is need, says the Chief Forester, to increase the cut of timber from the national forests wherever a fair price can be obtained for the stumpage, because a great deal of it is mature and ought to be taken out to make room for young growth. Unfavorable conditions in the lumber trade caused new sales of national forest timber to fall off somewhat during the past year, though the operations on outstanding sales contracts brought the total cut above that of the previous year by 130,000,000 board feet. There was, however, a big increase in small timber sales, these numbering 8,298 in 1914 against 6,182 the previous year. Desirable blocks of national forest timber have been appraised and put on the market, and it is expected that these will find purchasers when conditions in the lumber industry improve.

After eight years of experience, stockmen are well satisfied, says the chief forester, with the way the grazing of live stock on the forests is regulated, and have even urged upon Congress the application of the same method of control to the unreserved public range. Almost 29,000 permittees graze stock on the national forests, and these paid to the Government in the fiscal year 1914 fees amounting to over a million dollars. The present tendency to raise fewer sheep and goats and more cattle and horses is shown in the fact that the number of cattle and horse permittees on the western forests increased last year by 1,579, while the number of sheep and goat permittees fell off by a total of 268.

Under another law, twenty-five per cent of the national forest receipts for the year, amounting to $586,593.39, were paid over to the various states in which the forests lie for the benefit of county schools and roads.

Since 1909, when systematic classification of national forest lands was begun, more than 10,000,000 acres have been eliminated. Scattered interior tracts which it is not practical to eliminate are opened to settlement through listing, which allows them to be taken up under the forest homestead law. Anyone may apply to have land within a forest examined to determine whether it is best suited for agriculture, and if found so it is opened to settlement under this law. During the year 2,690 tracts, totaling 282,483 acres, applied for by individuals, were opened for entry. By elimination and listing, the percentage of unpatented agricultural land within the national forests, never lare, has been reduced to a very small amount.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for February; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "Odorous Flowers of Texas," Cecilia A. Middlebrook; "A Botanist's Suggestion for a National Flower," E. F. Andrews; "A Pollinating Contrast," Albert A. Hamen; "Food from Wild Plants."

American Journal of Botany; Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy: "The Influence of Illuminating Gas and Its Constituents on Certain Bacteria and Fungi," C. A. Ludwig; "A Bacteriological Method Useful for the Study of Other Microorganisms," Freda M. Bachmann; "The Development of Some Exogenous Species of Agarics," Gertrude E. Douglas.

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American Mathematical Monthly, for January; *27 King St., Oberlin, Ohio; $3.00 per year:* "Bibliographical Notes on the Use of the Word 'Mass' in Current Text Books," Edward V. Huntington; Problems and Solutions.

Educational Administration and Supervision; Hershey, Pa.; $2.50 per year, 40 cents a copy: . "The Administration of Public Education in War Times," George Drayton Strayer; "The War and the Curriculum of the Public Schools," Lotus D. Coffman; "The War and Secondary Education," Alexander Inglis; "The War and Vocational Education," David Snedden; "The War and Methods of Instruction," W. W. Charters; "The Training of Teachers as a Phase of Democracy's Educational Program," W. C. Bagley.

Journal of Educational Psychology, for January; *Lancaster, Pa.; $3.00 per year, 35 cents a copy:* "Some Mathematical Aspects of the Binet-Simon Tests," Francis N. Maxfield; "The Measurement of Intelligence: Six Hundred and Fifty-three Children Examined by the Binet and Porteus Tests," S. D. Porteus; "Freshman Tests at the State University of Iowa," Irving King and James M'Crory.

Journal of Geography, for March; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Agriculture on the Nile Delta," V. C. Finch; "Russia in War Time" (Reprinted), H. V. Winchell; "Pronunciation of Certain Place Names," R. M. Harper; "Streets of Cities," Frederick Homburg; "Supplementary Work in the Teaching of Geography," E. S. Clem.

Nature-Study Review, for February; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Science and Nature-Study," S. C. Schmucker; "The Spirit of Nature-Study," Cora A. Smith; "The Correlation of Nature-Study in the Platoon School," Julia Shourek; "Some Mechanical Aids in Nature-Study," Wm. G. Vinal; "The Opportunity for Research in the Problems of Teaching Nature-Study," Elliott R. Downing.

Popular Astronomy, for March; *Northfield, Minn.; $3.50 per year:* "A Unique and Famous French Observatory," Charles Nevers Holmes; "A New Form of Mounting for Large Reflectors," Russell W. Porter; "What Was the Star of Bethlehem?" Stansbury Hagar; "Relativity in Astronomy," W. Carl Rufus; "On Selecting Stations for Totality of 1918, June 8, and Probable Cloud Conditions at Eclipse Time," David Todd; "Eclipse Stations in Oregon and Washington," Sydney D. Townley; "A Simple Plan for Unifying Time in the United States," Jermain G. Porter; "Report of the American Meteor Society for 1917," Charles P. Olivier.

Physical Review, for February; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Brightness Sensibility of the Retina," Julian Blanchard; "The Moment of Momentum Accompanying Magnetic Moment in Iron and Nickel," John Q. Stewart; "A Study of the Fluorescence of Certain Uranyl Salts at Room Temperature," Frances G. Wick; "Proceedings of the American Physical Society."

Teachers College Record, for January; *Teachers College, New York City; $1.50 per year, 40 cents a copy:* "Schools in War Time and After," Arthur D. Dean; "Practical Arts in General Education," David Snedden; "School Statistics for the Public," Carter Alexander; "Games Involving Number," Louise S. Steinway; "Value of Household Arts Education," Frederick G. Bonser; "High Standards of Living at Low Cost," Anna S. Matthews; "Tested International Recipes," May B. Van Arsdale and Others.

DO YOU HAVE SUPERVISED STUDY IN PHYSICS?

Inasmuch as I have been asked to discuss in some detail the problem of supervised study in physics at the coming spring meeting of the Conference of Affiliated Schools with the University of Chicago, may I urgently request every teacher who has tried supervised study in physics classes to send me *at once* a definite and comprehensive statement as to the result of the experiment? Due recognition in the report and in the account to be published later in this magazine will be given those who promptly comply with this request. Address E. L. Harrington, School of Education, University of Chicago.

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A Journal for All Science and Mathematics Teachers

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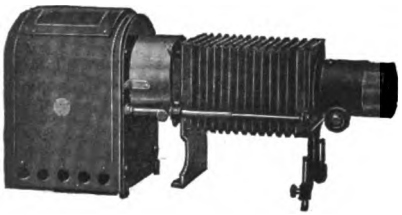

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 5 MAY, 1918 WHOLE No. 151

PROGRESSIVE TEACHING OF MATHEMATICS—WHAT IS IT ?[1]

By G. W. MYERS,

University of Chicago.

Members of the Club: If I were a sufficiently staunch republican in politics, as I used to be, I would not admire the adjective in my title. I presume I should prefer the phrasing "stand-pat" mathematical teaching. But nowadays I am not sufficiently staunch. If I were sufficiently "dyed-in-the-wool" democratic, perhaps I should prefer "Reform" mathematical teaching. But I am not sufficiently partisan even at this angle of bias. Furthermore, I shall assume that there is amongst you a sufficient degree of political detachment to tolerate the adjective, progressive, as a qualifier of mathematical teaching.

What shall a mathematical teacher do today to merit being regarded as a progressive teacher by his professional colleagues? In this day of school surveyors, gap-bridgers, critics, iconoclasts, and general fault-finders, when to the staid educationist it looks as though the experts were running amuck through the educational world in general, and through mathematical education in particular, it is not easy to answer this question well. The answer, however, is none the less desirable, and I shall at least try to give my form of answer.

THE ATTITUDE OF THE PROFESSIONAL TEACHER.

In the first place, what one should do to be regarded as a progressive mathematical teacher must depend on the nature of the situation in which he has contracted to teach. If one must teach under a rigid curriculum, fixed by the authorities beyond the pale of redemptive activities, he should neither chafe nor quail, but calmly accept the inevitable. The progressive teacher in such a situation, and this type of situation is numerous, will rather direct his efforts at making the very best

[1]Talk to the City Mathematical Club on Friday evening, January 11, 1918.

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he can out of the existing order than waste them in trying to remedy the irremediable. He will do best by following the conventional procedure. But even here he may avail himself of the pedagogic fact that we spend too large a proportion of our time and effort in merely exemplifying and illustrating mathematical principles and too small a proportion in teaching how to solve social and everyday problems with the aid of the mathematical tools. Even in such a situation I would enrich the work with more applications in which the toolage advantages of the school mathematics would become apparent. This much may be attempted by even the timid teacher without jeopardizing his position.

If the fixed curriculum were distinctly poor, I should now and again hint of ways in which it might be made better. I would, however, be careful to let the principal or superintendent have the first chance at the honor of doing the improving, and would undertake it myself only on the request of this usually jealous official. Of course, the main reason that mathematical teachers have influenced mathematical curricula so slightly is that they have been allowed so little opportunity to influence it. But when educational people go about saying that the mathematical specialist has had his day with the curriculum, has failed to profit by it, and that now the improvement of mathematical courses should be turned over to others, it is well to remember that "his day" was usually usurped by some "superior official." In the fixed situation, the progressive teacher of mathematics will strive to be "as wise as a serpent and as harmless as a dove."

There are, however, numerous situations in which a level-headed mathematical teacher can do about as nearly as he pleases with the mathematical course of study and the special courses that make it up, as a single member of a necessarily correlated corps of teachers ought to want to do. The kind of use the favored members of our profession who function in such situations make of their opportunities is of the very highest significance for the improvement of our work. It is they to whom we are to look for the first formulations of general plans for new advances and for the smoothing out of the first steps in bringing the new formulations into practicable shape for average conditions. The progressive teacher whose good fortune has placed him in one of these favored situations will today give close attention to the following points:

I. He will see to it that his attitude toward attacks from

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professional critics upon his subject and upon the results of his work as teacher is professionally correct. Attitude in mathematical matters means much more than many people think. For example, no clearer basis for differentiating the separate fields of arithmetic and algebra has yet been offered than that of attitude toward problems. If the attitude is to find the solution of this particular problem, the problem is one of arithmetic. If it is to find the solution of this type, or class, of problem, we have an algebraic problem. Right attitude implies the correct position for an economical start. "Well begun is half done" is more than an adage in mathematical matters. But the particular phase of attitude I am here emphasizing is attitude toward attack. It is no secret that we are being vigorously attacked nowadays both as to subject-matter and methods.

Of the attitudes that have found spokesmen from one quarter or another the following four are prominently in evidence:

1. The neutral attitude.

This attitude expresses itself in such phrases as, "Mathematics is good enough. Let it alone." "If you ask us, 'What are we going to do about it,' we answer, 'Nothing.' " "What was good enough for grandfather, is good enough for us." Their counsel is: "Go into the cyclone cellar and wait for the storm to pass." In spite of some very disturbing facts against the adequacy of the results and the time and effort of mathematical teaching in public high schools that entirely conscientious and capable experts have brought out to view, the neutral says: "This is no concern of mine," or "Let the heathen rage," or "These crazy folk, having no real subject-matter to talk about publicly, must trump up talk about some bugaboo that will give them a hearing." The neutral attitude is very far from the attitude that the progressive teacher will take.

2. The belligerent attitude.

The spokesmen of this attitude counsel: "Blow up the enemy." "Get in the trenches of tradition and convention and 'stay put.' " Or in the *patois* of partizan politics their counsel is "stand pat." They attack the character of the enemy by suspecting that he had early trouble with his school mathematics and can't forget it, or that he now has a son or daughter who cannot learn mathematics. But this "mailed fist" type of argument gets nowhere, convinces nobody, and harms only its user. The progressive mathematical teacher will shun it as

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he would the plague, for it is stultifying to every participant.

3. The clerical attitude.

This is the attitude of reverence for the past. What educators and thinkers for over two thousand years have regarded as fundamental and essential educational material must not now be called in question. It is a sort of educational sacrilege to pit one's individual judgment against the consensus of the ages. The past fruits of present curricular forms in the lives of great men or successful men, who testify to its benefits, ought to quiet attacks upon their present worth. This attitude is a flat denial of progress, fixes the stationary upon us, and cannot be assumed by the progressive mathematical teacher of today. It is the ancient Egyptian view and is unprogressive. We dare not forget—

"New occasions teach new duties, time makes ancient good uncouth."

In this day, when men's views are undergoing profound changes, when long cherished ideals are being replaced by new ones almost over night, we cannot hope for appreciable help from the clerical attitude.

4. The psychological attitude.

In the last twenty-five years a new attitude toward educational questions has been gradually working its way into the minds of men. Many middle-aged and older teachers of the conventional school subjects, teachers whose standards of educational worth were worked out to their own satisfaction before the new attitude had matured, have no adequate appreciation of the worth of psychological norms and standards, even though they may have found time now and then in their busy pursuits to do a little desultory reading in psychology. Indeed, it is the failure to recognize the psychological attitude toward educational questions that furnishes representatives for the three attitudes enumerated above.

The reason for the discomfiture, where it exists, among mathematical specialists, particularly among professors of mathematics in colleges and universities, at the recent propaganda against school mathematics as organized and administered in current curricula, is that these persons have no psychological point of view at all. It is not a wrong point of view that causes the discomfiture, it is the complete lack of a psychological point of view. This is also the cause of the repeated appearance of the same old objectionable form of textbook for high school mathematics. The author has no psychological attitude at all

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toward the problem of mathematical teaching, which is pre-eminently a psychological problem. The attitude of the author is either *empirical*—mere habituated classroom procedure—or it is purely *mathematical*. The author tries to produce a good text. He has no malice toward a good text. He simply doesn't know what a good teaching text is, separate and apart from the grooves of his habituated practice. His weakness is not glaringly revealed yet, for the choosers of texts are as lacking in psychological attitude as he is. Moreover, the users of the text thus chosen have been merely habituated to the same type as has the author himself. The whole cause of the attitude of pugnacity toward the school critics of mathematics grows out of lack of any psychological attitude, while at the same time the tenacity of the present unsatisfactory *status* of high school mathematics is due to the same lack in school people who occupy critical places between the author and the child. The progressive teacher will not unduly quarrel with this *status* of things. He will simply recognize it as a fact, will see to it that he himself has a psychological attitude, will seek encouragement in the thought that as the more recently qualified recruits to the ranks of teaching become more numerous and influential, this condition will be corrected, and he will regard these extra-mural attacks as corrective agencies. The progressive attitude must be the psychological attitude.

The psychological attitude implies an ability and a willingness to see a fault, even when it is one's own. It demands open-mindedness to arguments both for and against. It does not regard change, even great change, as sacrilege, but rather as a professional need, if not necessity. It meets argument with argument. It neither coaxes nor cajoles; neither grouches nor grumbles; resorts to neither poisoned gases nor organized resistance. It believes in the ultimate perseverance of the saintly. It is always pacifically perseverant along established lines of principle. The psychological attitude is the progressive attitude today.

The Views of the Professional Teacher.

II. Right attitude starts one right, but right views are what hold him right. The progressive teacher must not only face and start right, he must keep right. Here again there are four aspects of educational view that the progressive teacher will not neglect.

1. The educational view.

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Of the vast body of mathematical material from which we might select what we will use for educational purposes, some parts are more appropriate than others. The educational view is that the mathematical material needed for the curriculum must be of the sort that faces both inward and outward. For example, the triangle is important because of its general relatedness to all sorts of plane rectilinear figures. The properties of nearly all plane figures may be derived by analyzing the figure into some form of triangle, after the properties of the triangle itself have been made out. This is the inward face of the theory of the triangle and from it comes the scientific value of the triangle. But many problems of construction, of surveying, etc., that arise in everyday life are solved by the aid of the theory of the triangle as a tool for general non-mathematical use. This is the outward face and from it the triangle gets a utilitarian value. Those parts of the general body of mathematical material that have both faces, the outward and the inward, are what should furnish curricula with their material. This principle will be an *accepted* and *working* view of the progressive mathematical teacher.

2. The mathematical view.

The mathematical view is that mathematical principles face only inward. Perhaps no high school teacher holds this as a conscious view for the control of teaching, but the difficulty is that he teaches, quite unconsciously, as though this were his view. He uses vocational or physical situations to exemplify, or to illustrate, mathematical principles, and uses them only in this way. He rarely, if ever, uses mathematical technique purely as a tool to resolve some scientific, or social or industrial situation. The text rarely, if ever, furnishes such situations for mathematical exploitation, and it is doubtful whether it should. But the teaching should not omit, nor even minify, this instrumental use of mathematics, for most young persons get whatever confidence they have in the worth of mathematical study from the feeling that such study confers power over the quantitative world. They develop an interest in the inward aspect of mathematical relatedness, some slowly, some rapidly, but all gradually as the mathematizing proceeds to later stages. Faith and interest in mathematical effort of both sorts, both that which aims at mathematical insight and grasp and that which exhibits power of use, must be the continual aim of the progressive teacher. He needs to be particularly careful not to read his own

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mathematical interest into the early classes. He should with them be continually employing the utilitarian possibilities on local and familiar problematic situations of an extra-mathematical character. Much more than the customary emphasis upon real applications in which well mastered mathematical principles function as real tools is what I am claiming the progressive teacher should do today.

3. The social view.

A third view is that school mathematics should have high value as giving social, occupational, and vocational insights and power. We have not yet found practicable ways of doing this. But we must not yet give up the task. It means teaching the formula, the equation, the function, the graph, logarithms, etc., much earlier than we do. This is the social view, and is one of the dominant notes of secondary education today. The progressive teacher will find some way of getting himself into friendly relations to it in practice. He will at least not ignore it, nor oppose it.

4. The rational view.

A fourth view that the progressive mathematics teacher must employ explicitly is what we shall call the rational view. It is that the teacher should charge himself with the professional duty of training his pupils to take a rational attitude toward their school tasks, to the end that they may come to assume this attitude toward the tasks of life. We know that youth are anxious to do the mere technique of mathematical work, and that they shrink from, sometimes even resent, trying to give the reasons for the doing. By the persistent "whys" of mathematics we can and should break up this shallow satisfaction and establish the real student attitude of wanting to know why. Progressive teachers will train to the rational attitude in mathematical study. This is a widespread and a crying need in our public schools.

The progressive mathematics teacher will keep his mind clear on all four of the views, the educational view of mathematics, the mathematical view, the social view, and the rational view, and conform to all of them as his ability and experience show him profitable ways of doing so.

The Values of Mathematical Education:

Right attitude and right views prepare the professional teacher for a scrutiny of the *values* of mathematical education. Critics of our work have claimed that there is no general agree-

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ment amongst us as to the aims and values of our work, and that whatever they are, our work is not realizing them with large numbers of our pupils. This, they say, is a strong reason why our subjects should be made elective. It is not my purpose here to enter a rejoinder. I do say that we may regard the following values of good school work in mathematics as almost, if not quite, universally accepted, and that it is the duty of the professional teacher to accept them and to undertake explicitly to secure an appreciable measure of all of them with all his pupils.

1. The formal value.

This means the value represented by a facile measure of skill in the direct use and manipulation of mathematical symbolism. Mechanical though it be, one will hardly make any sort of use, instrumental or scientific, of mathematics, if a considerable part of his mental energy is used up in the mechanics of mere symbol manipulation, and only the *residuum* is available for energizing against the problem. Without sufficient skill in mathematical mechanics for easy manipulation, mathematical symbolism actually encumbers thought, and is a nuisance. Enough skill to keep mechanics out of the way of thought is the ideal, and the progressive teacher will not fail to strive at least for this degree of formal skill.

2. The literary value.

This means the value represented by the ability to interpret popular scientific articles and books. This ability is needed by every high school pupil, and the progressive teacher of mathematics will secure it.

3. The instrumental value.

This is only a higher measure, which can be attained by many high school pupils, of the literary value. It means the ability to read and interpret intelligently scientific and professional subject-matter of the precise quantitative sort. It is to include also the ability to use the technique of mathematics in dealing with scientific and engineering facts and principles. The progressive teacher will give considerable attention to attempts to realize this value, especially in the later courses.

4. The scientific value.

This value is intended to include what may be called the vocational or mathematical value. It is such a degree and kind of mastery of elementary mathematical *technique* and *rationale* as the prospective specialist in mathematics must have. This

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value perhaps need not be insisted on here, for it is the sort of value we are now almost universally attempting to secure for all. I mention it here because it must not be neglected by the progressive teacher, even though other values are just now crying loudly for more attention than we are giving them.

5. The transfer value.

Mathematicians and mathematical teachers are in sufficiently full agreement as to whether this phase of value exists, and the professors of education, formerly considerably at loggerheads about it, are coming to an agreement that something carries over. Precisely what it is that carries over, and to what extent it carries over, remain yet to be answered. That some sort of gain in attitude toward problem thinking and some measure of the technique of problem solving goes over into fields in which problem thinking is characteristic is conceded by nearly everyone. If we should make our teaching such as to call for a great deal more problem thinking from the pupil, we shall surely be increasing this value of mathematics. Learning model demonstrations is not problem thinking, nor is symbol juggling. Problem thinking is analyzing, organizing and controling problematic situations—situations which produce the dilemma attitude in the learner's mind—and we do too little with this sort of thing in our classes. There is too much "fixing things up" so that the pupil may never be troubled by a dilemma, too much teaching him everything he needs before he needs it, to admit of much training in problem thinking in our present day teaching. The progressive teacher will produce some dilemmas for the pupil himself to dispel. More important mathematical things should be taught obliquely, as tools needed in problem solving.

Norms for Gauging Mathematical Values.

The progressive teacher will seek to aid in setting up standards for judging the special achievements of mathematical study. Such questions as: "Does an ever widening deviation of abilities in your class indicate good, bad, or indifferent teaching?" can be answered by the high school teacher in the pursuit of his regular work. I raise the question: "Why is an ever widening deviation in abilities in high school classes in mathematics so general today?" The progressive teacher will associate himself as occasion offers, as our chairman has been long doing, with some professor of education and help to set up suitable

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study tests, ability tests, and attainment tests. While the psychological and the mathematical attitudes are so divergent as they now are, this is a practicable way of getting both attitudes in function. Perhaps a standard grading system might be worked out thus. We always have a higher regard for the ideas of a man with whom we have worked than we have from just hearing him recite our weaknesses. Let us get together. Instead of chafing under the findings of the school surveyors, it will be much more progressive for us to help set up more adequate standards, and then after weaknesses have revealed themselves let us be broad-minded enough to bestir ourselves to remove them.

A Closing Reminder.

Just one more reminder in closing. Nearly every educational writer and general educational authority who has recently tried to give us suggestions for constructive improvement has urged that we introduce the formula, the graph, and logarithms in the first year high school course in mathematics. None of us is even attempting to do this, nor has any good reason for not trying this as yet appeared. Why is this? Do actual teachers regard these suggestions for modernizing high school algebra as of no value? Has anyone tried out these suggestions? The recent texts are doing a little half, or quarter-hearted work with the graph. But the formula and logarithms are not seriously tried by anyone. Why is this? I close with the question, without even asking why not introduce the function idea earlier in algebra.

MEETING OF THE TEACHERS OF SECONDARY SCIENCE OF DISTRICT I, VIRGINIA.

This meeting was held with the Science Club of the State Normal School for Women, on Friday, March 15, during the Educational Conference which met at the Normal, the 14th, 15th, and 16th. A round table discussion, conducted by Miss Flora Bryson, Head of the Science Department of Radford State Normal School, created considerable interest. The topic, "First- and Second-Year Science in the High School," was discussed from the standpoint of the tendency to substitute agriculture and domestic economy for physical geography and the biological sciences. An encouraging feature of the meeting was the presence of superintendents and college men who exchanged views unreservedly.

Miss Bryson read a paper before the patriotic session on Saturday, urging better science teaching in the high school in order to give "more of the ninety-five per cent a chance," and thus increase the number of men and women from whom the nation is to draw her scientists for research.

Flora Bryson.

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MAKING WALL MAPS OF LIMITED AREAS.

ROBERT M. BROWN,
Normal School, Providence, R. I.

In teaching geography of the home locality, it is frequently necessary to have maps of areas of which map publishing houses cannot supply the needs because of the limited demands. Most town, county or state maps which are available are not issued primarily for teaching purposes and the copies which are used are ordinarily constructed for close study not suited to classroom uses. Teachers must be depended upon to supply this lack and prospective teachers need some training in preparing for their classrooms or in translating to the blackboard the maps and charts necessary to the best presentation of the lesson. In a state as small as Rhode Island, it is possible to mount the topographic sheets of the United States Geological Survey covering the whole state on a single canvas and the resulting map is, from the point of view of size, convenient and satisfactory. As a wall map for class use, however, it falls far short of perfection. The outline of the state and the counties stand out in fair prominence but no other feature can be read with any degree of comfort or accuracy. The contour lines, which on some combinations of the topographic sheets are discernible across a room, on the Rhode Island map, because of the low relief, sink into insignificance. A few maps of Rhode Island are published, but there is no map which is fitted to be exhibited on the walls of a schoolroom for a class exercise in Rhode Island geography. This condition, with varying degrees of emphasis, is true of most parts of the United States.

The process of preparing on cardboard or blackboard a map suitable for the use of a class is outlined below. A Rhode Island map ready for enlarging is inserted as a sample. On this map the short dashes are town boundaries, the short and long dashes mark the county boundaries, and the dotted lines the 100 and 500 foot contour lines.

ENLARGING.

A. Select a map for enlargement which contains the features desired. If no such map exists, it may be necessary to reproduce one, as has been done in the case of the Rhode Island map with which this paper is illustrated. The outline with town and county boundaries may be taken from an atlas, and upon this as a base the contour lines may be inserted from the topographic sheets

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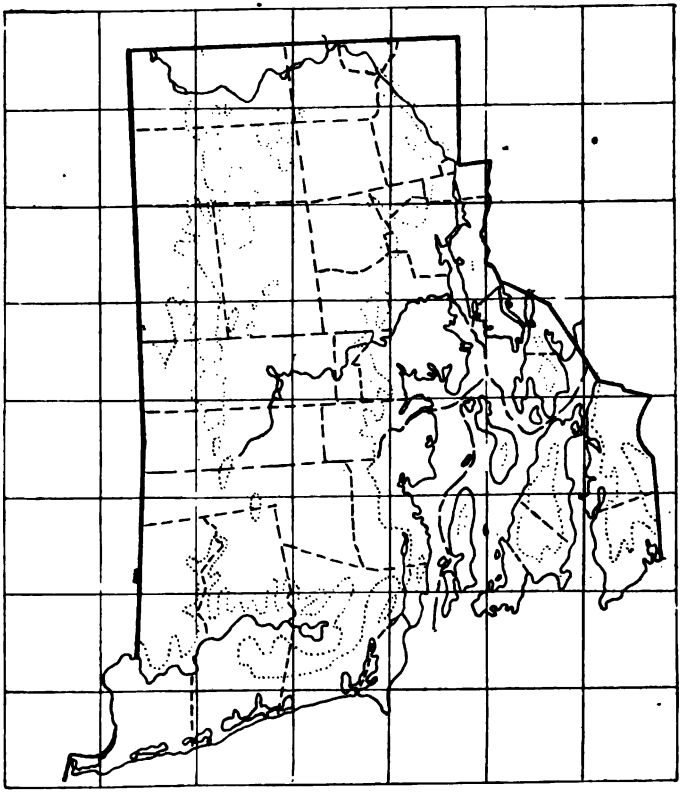
of the Geological Survey or from any other authoritative source. The contour lines of the Rhode Island map are taken from the International Map of the World (1:1,000,000 Sheet K-19 U. S. G. S.), and the Topographic Sheets for Rhode Island.

On the map to be enlarged draw squares completely covering the section desired, as in the figure. The size of the squares must be determined by the detail of the map. In general, one centimeter or one-half inch squares may be the rule.



B. Select a sheet of heavy white paper for the map. The commercial size (28½ by 22½ inches) makes a map of suitable clearness if the map is devoted to a single feature. On this paper make the same number of squares as on the smaller map (eight by seven in the Rhode Island illustration), each square in this case being as many times larger than those of the original map as the size of the paper permits. Three inch squares on the Rhode Island map to be constructed would take 21 inches in width and 24 in length, leaving an ample margin.

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Do not make the lines of the squares on the cardboard prominent; the lightest line possible will avoid the necessity of erasing and the sizing of the paper will not be marred. The squares should be made carefully: squares mixed with rectangles will distort the map.

C. When this has been prepared, draw on the enlarged network, square by square, the map as it appears on the smaller network. This may be done free hand without any loss in effectiveness or accuracy. Locate by the same process such political boundaries as are desired, rivers, lakes, cities, islands and any other feature.

OUTLINING.

D. Draw the boundary line of the area following the pencil mark which indicates it, with a red crayon (madder lake) for land boundaries and blue (ult. blue) for river and coast lines. The difference between the political boundaries of the state and the political boundaries of town or county may be indicated by the width of the line or by continuous and dotted lines. Draw a margin (black) around the area mapped so as to center the figure and finally cut the cardboard so that the edges may be properly located with reference to the marginal lines. This will give an outline map of classroom size on which may be charted such geographic features as form the subject of the lessons.

CHARTING.

E. Maps displaying climatic data, natural resources, transportation lines, location of industries and density of population are valuable in teaching. A uniformity of condition in any one of these lines which exists over the whole area need not be charted. Thus, if the annual rainfall does not vary in any appreciable amount within the limits of the mapped area, a rainfall map will not be worth while. The Census Bureau of the United States has issued state maps showing densities of population by counties but in many cases, as in Rhode Island, no lesson can be drawn from them, while a density of population map by towns displays definite and clear responses to topography and transportation routes. Conventional signs for all of these features are given in most geography textbooks. The contour lines may be omitted from these maps as confusing detail.

TOPOGRAPHY.

F. The topographic wall map of any small area which is taught as a unit in the geography class is an invaluable aid.

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It is sometimes argued that the construction of these maps by the teacher adds another task to her already busy day. The time wasted in teaching lessons on the topography of Rhode Island, for instance, without a proper map is much more than sufficient to construct all the Rhode Island maps necessary for use in the grade schools.

In making a topographic map, the contour lines are necessary. Proceed with the coloring for topography. Use green (medium green) for heights up to 500 feet. In areas of low relief, as in Rhode Island, two shades of green may be used and the 100 or 200 foot contour line, as is convenient, may separate them. For heights between 500 and 1,000 feet use brown (a light application of burnt sienna); between 1,000 and 2,000 feet, brown (a heavy application of burnt sienna); between 2,000 and 5,000 feet, dark brown (a light application of burnt umber); between 5,000 and 10,000 feet, dark brown (a heavy application of burnt umber); and above 10,000 feet, magenta. For water bodies use blue (ult. blue).

Begin all shades with light strokes. It is easier to darken the shade than to reduce it. Apply all colors with a horizontal stroke. This will give a uniformity to the effect and avoid scratchiness. Do not cross boundary lines in coloring and do not run into boundary lines, as the colors will mix.

LEGEND.

G. The legend of the map may now be added. A small rectangle within the marginal boundary lines may be used for this purpose. A scale should be inserted under the caption. This may be taken from the original map by enlarging it according to the square method to the corresponding size of the wall map. The explanation of the colors or of the information charted may be made according to the methods employed by any good map as the topographic sheets of the United States Geological Survey. Direction symbols, either an arrow or parallels and meridians, should be added.

In making wall maps, it will be found upon trial that the best results in the grades are gained from maps which display a single feature. No general rule, however, can be made as the states differ in kind and amount of detail. In Rhode Island it is possible to place upon the topographic map the town boundaries, the city centers and the railroads without causing confusion. Another map is needed to show density of population. The productions of the state cannot, because of their variety and range, be easily charted on a single sheet.

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THE OIL IN CHERRY PITS.

By HAROLD L. MAXWELL,
Cornell College, Mount Vernon, Iowa.

It has been the subject of much speculation as to how the Germans have been supplied with fats for food and to furnish the glycerine from which the important explosives, dynamite and nitro-glycerine, are made. They have been charged with having extracted fat from their enemy dead to be used in making the explosives.

An important source of oil in Germany is doubtless the cherry pits, and it is quite likely that German thrift and efficiency would not be slow to utilize that material. There is scarcely any other country on the globe where the cherries have reached so high a degree of perfection as in Germany. Cherry trees are everywhere and the cherries are unusually large and constitute an important article of food during the early summer. We thought it might not be devoid of interest to investigate the oil content of the cherry pits.

We secured a quantity of the dried seeds of the common cherry, "Prunis Erratus," and by cracking we obtained fifty grams of the kernels. These we crushed in a mortar, removed to a cloth sack and placed in the flask of the ether extraction apparatus. The oil which adhered to the mortar as a result of the crushing was washed with ether and added to the contents of the flask.

After the extraction had continued for fifty-six hours, the oil laden ether was taken from the extraction flask and great care was exercised in order to insure against the loss of even the smallest quantity of the oils. The ether and oil mixture was distilled at the lowest possible temperature. The boiling point of the ether being 34.9° the mixture began to distill at a slightly higher temperature, about 36° C. By fractional distillation the oil was separated from the solvent. To insure the evaporation of all the ether, the oil was placed in an open beaker and heated on a water bath at 76° C. for three hours. After this treatment even the faintest trace of ether could not be detected.

The yield was unusually large. From the fifty grams we secured 18.8 grams of the oils or a yield of 37.6 per cent. The oils have the characteristic odor of almonds. The taste is pleasant, resembling nuts. They are light amber in color and have about the consistency of warm castor oil.

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The German Pharmacopeia states that pure almond oil should remain clear at -10° C. This specimen became opaque, showing that we had a mixture of oils and not one individual. At low temperatures the oils showed marked changes. The first change in color began at -5° C, when white globules separated out and settled to the bottom. This indicated that one of the oils solidified at that temperature. We kept that temperature constant until all the oil which had a tendency to solidify had separated out. We set this oil aside for further study, which we record later. The amber oil, which constituted about 90 per cent of the whole oil content, was drawn off with a pipette and subjected to lower temperatures. At -18° C there was no sign of solidification but at -19° C the oil became viscous, while at -20° C it began to become solid.

The specific gravity of the oil was next determined by weighing out several portions of two cubic centimeters each on a watch glass of constant weight, and computing the weight per centimeter of the oil. We found the sp. gr. to be .922, .925 and .924 in three respective cases. This is consistent with the results secured by T. Maben, who investigated the oil in almond nuts. He records the sp. gr. of that oil as .918 to .923.

Two grams of the oils were weighed out on a constant watch glass and set aside at room temperature for a period of forty hours. After that time the oil was weighed again, noting the loss in weight. The oil is slightly volatile, since during that period it had lost $1\frac{1}{2}$ per cent of its original weight.

In determining the saponification equivalent of the oil under examination, we first prepared a normal solution of KOH in absolute alcohol. This was done by dissolving 56 grams of KOH in 800 cc. of the solvent and then diluting to a litre. We weighed 4.317 grams of the oil into an eight ounce flask and added to it exactly 30 cc. of the alcoholic solution of KOH. The flask was connected with an inverted condenser and the contents kept at a boiling temperature for thirteen hours. We cooled the flask and added 200 cc. of water. Then to determine the amount of the oil which had been saponified by the KOH, we titrated the contents of the flask with normal HCl, using phenolphthalein as an indicator. The difference between the number of cubic centimeters of the normal KOH used and the number of centimeters of normal HCl necessary to neutralize the remainder after the saponification represents the number of cubic centimeters of the KOH neutralized by the oil. Then,

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knowing the strength of the solution and the nature of the oil, we can determine the percentage of the saponifiable oil. The saponification equivalent is the object of this experiment, and to compute that we divide the weight of the oil in milligrams by the number of centimeters of KOH solution neutralized by the oil. In this case we found it to be 276.8. E. Valenta investigated the oil from almond nuts and found the saponification equivalent to be 285, and that in some cases it ranged as high as 296, depending on the purity of the specimen. Thoerner, in a study of the mixed fatty acids of almond oil, found the equivalent as low as 204.

Taking first the light amber oil, which constituted the main portion of the mixture of oils, we added two drops of concentrated sulphuric acid to twenty drops of the oil. At first there was no color, but on stirring with a glass rod the oil and acid mixture became brown and in a few minutes it began to solidify. This also is characteristic of almond oil.

Some of the smaller portion of the oil which had separated out on being cooled in the first part of the investigation was given the same treatment with a few drops of sulphuric acid. When the mixture was stirred, the color turned from a yellow to a reddish brown with a purple cast. This indicated the presence of Arachis oil, the principal oil in peanuts. There was only a small amount of this oil present in the specimen. This was not sufficient for a complete and thorough analysis.

There are three sources from which almond oil may be obtained: Almond nuts, peach kernels and apricot kernels. Then since the cherry seed belongs to no one of these three classes, our next question might well be: Which one of the three does it most resemble?

Samples of almond oil from each of the three sources vary in specific gravity, bromine absorption, and color tests. In the first two instances the variation is so slight that, allowing for even the smallest error, the line of difference is indistinct. It is then the color tests that mark the dividing line between the almond, peach, and apricot oils. The zinc chloride test is the one employed as follows: Add five drops of the strong zinc chloride solution to ten drops of the oil. If there is no change in color after stirring, the oil is identical with that from the almond nut. If the color changes to purple or brownish purple, the oil is from the peach kernel. While if the mixture changes to a muddy or a dirty brown, the oil is the same as that from the apricot kernel. In the sample of oil being examined there

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was no change of color, showing that the oil in this analysis is the same as from the almond nuts.

The taste and odor of cyanogen in the freshly cracked cherry pits is evidence of the presence of nitrogen. By the use of the Gunning method we determined the percentage of nitrogen in the kernels and found no less than 5.6 per cent. It is to be expected that the ether extraction would remove a part of the cyanogen with the oil. We took a gram of the dried residue after all the oil had been extracted and made another nitrogen determination. In this we found 4.2 per cent of nitrogen, showing that the main portion of the nitrogen was neither extracted by the ether nor expelled by the long heating on the water bath.

The residue from the crushed cherry pits was taken from the flask and dried in the air for ten hours. Then it was heated on the water bath at 100° C for fifteen hours to expel the remaining ether and the moisture. The dry residue was weighed and the loss in weight found to be 20.9 grams. The oils extracted weighed 18.8 grams, leaving a difference of 2.1 grams. This is no doubt the weight of the water expelled from the residue when it was heated to drive off the remaining ether.

When cherry seeds or oil bearing nuts are ground up with cold water, the amygdalin breaks up in an emulsion. The oil is partly broken down in the process and glucose sugars constitute one of the resulting products. To confirm the presence of the glucose sugars in the water extraction, we treated a quantity of the dried seeds with water for twenty-four hours. We titrated a fractional part with standard Fehling solution and found 13.8 per cent of sugars present. Reaction:

$$C_{20}H_{27}NO_{11} \pm 2H_2O = C_7H_6O \pm HCN \pm 2C_6H_{12}O_6$$

The cherry oil, which has been found to be essentially the same as the almond oil, consists of olein with a small quantity of stearin and palmitin. Olein is the chief constituent of the fatty oils and may be made by heating glycerine with an excess of oleic acid at 204° C. Its formula is $C_{57}H_{104}O_6$.

It is not to be expected that the Central Powers, with their urgent need of oil for food and explosives, have overlooked such a productive source of glycerine as we have found in the cherry pits. The production of the countless tons of explosives necessary to carry on a war has called into service every resource of the nation. This is an item, then, not to be underestimated, for already the cherry seed oil has contributed its bit to the great world war.

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PERSONAL JUDGMENTS AS A FACTOR IN GRADING.

By J. L. ZERBE,

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After the class had completed over a half year's work in psychology and had had some animated discussions on personal judgments in school grading, they were asked to rank according to merit, best first, next best second, etc., and to grade in percentage figures five specimens of a half-lap joint. The class was composed of nine adult students in a technical school, who had completed a year and a half of woodwork; some were grading wood projects in their substitution teaching in the public schools, and each had had the criticism and grading of his own half-lap specimen by the instructor of manual training. Some uniformity in grading such a specimen might be expected. The following tabulation gives the results of these personal judgments in ranking and grading of the five specimens:

	Ranking of Specimen					Percentage valuation of Specimen				
Student	1	2	3	4	5	1	2	3	4	5
A	1	3	3	5	1	80	65	65	50	80
B	2	4	5	3	1	78	75	72	77	80
C	2	3	4	5	1	90	85	80	75	95
D	2	4	5	3	1	84	78	75	80	85
E	2	2	2	2	1	65	65	65	65	75
F	1	3	4	5	2	90	75	70	65	80
G	2	4	5	3	1	81	73	70	76	85
H	2	5	4	3	1	80	60	69	73	90
I	1	2	5	4	2	90	80	60	70	80

It will be noted that only three students, B, D, and G, agree on the rank placement, while there is no agreement as to the percentage grading. One of the students grades four specimens the same, while other students rank these four from first to last place and give a percentage valuation from 50 to 90.

On four subsequent weeks these same students were asked to re-rank and re-grade these specimens. The students did not anticipate a future grading, nor were they allowed to refer to their former grades. In order to safeguard any carrying over from week to week, each specimen was given a new number each time, thus losing its former identity. The variation in the amount of percentage, the average grade given at each date, and the average variation which represents the deviation of the average percentage of any one time from the total average of the five dates for each specimen are given in the accompanying tabulation. At the bottom of each column is the deviation for each specimen for each time, the deviation of the variation, the total average grade and the total average variation.

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The recapitulation indicates that without some standard one judgment is as good or as faulty as any other. Student A, whose average is 65, has a different standard for work accomplished than has student C, who places the valuation at 85. A variation of twenty points on an average scale of 100 is a big step, yet each student considered his judgment as more or less absolutely fair. Student A places the poorest specimen 45 points lower than his best specimen; while B separates his by only 15 points. The judgments of the individual vary as much from time to time as do the judgments of different individuals.

GRADING OF HALF-LAP JOINT.

Student A	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	80	65	65	50	80	30	68	3
March 17	60	70	50	75	85	35	68	3
March 24	65	40	50	75	80	40	65	0
April 7	60	50	70	80	85	35	62	3
April 14	50	65	75	80	85	35	71	6
Variation	30	30	25	30	5	10	65	15

Student B	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	78	75	72	77	80	8	76	2
March 17	70	75	77	80	82	12	77	1
March 24	80	73	78	75	85	12	78	2
April 7	85	72	79	75	82	10	79	1
April 14	72	83	75	80	85	13	79	1
Variation	13	11	7	5	5	5	78	7

Student C	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	90	85	80	75	95	20	85	0
March 17	80	90	75	85	95	15	85	0
March 24	90	85	80	75	95	20	85	0
April 7	85	80	75	90	95	20	85	0
April 14	75	90	80	85	95	20	85	0
Variation	15	5	5	15	0	5	85	0

Student D	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	84	78	75	80	85	12	80	5
March 17	60	55	65	85	90	35	71	4
March 24	85	60	70	60	90	30	73	2
April 7	88	65	75	70	65	23	73	2
April 14	85	85	75	65	90	15	80	5
Variation	28	30	10	15	25	23	75	18

Student E	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	65	65	65	65	75	10	67	6
March 17	70	70	75	80	85	15	76	3

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March 24	80	75	80	75	85	10	79	6
April 7	70	60	75	65	85	35	71	2
April 14	60	80	65	60	85	35	70	3
Variation	20	20	15	20	5	25	73	20

Student F

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	90	75	70	65	80	15	75	0
March 17	90	85	75	80	87	15	83	5
March 24	85	80	70	80	90	20	81	3
April 7	85	65	60	75	80	15	73	5
April 14	60	83	77	73	85	23	76	2
Variation	30	20	17	15	10	8	78	15

Student G

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	81	73	70	76	85	15	75	1
March 17	69	76	79	85	88	19	79	3
March 24	84	65	71	60	90	30	74	2
April 7	85	70	79	75	85	15	78	2
April 14	71	80	65	60	85	25	72	4
Variation	16	15	14	25	5	15	76	12

Student H

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	80	60	69	73	90	30	74	2
March 17	60	60	65	85	90	30	72	0
March 24	85	65	70	60	90	30	74	2
April 7	90	60	65	60	85	30	72	0
April 14	60	80	85	60	85	25	70	2
Variation	30	5	20	25	5	5	72	6

Student I

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	90	80	60	70	80	30	76	3
March 17	60	65	70	80	90	30	76	3
March 24	90	75	85	80	95	20	85	6
April 7	85	65	80	79	90	25	78	1
April 14	70	90	80	65	95	30	80	1
Variation	30	25	25	15	15	10	79	14

Recapitulation

Students' Average		Total Var.	Grades Lowest	Highest
A	65	12	40	85
H	72	6	60	90
E	73	20	60	85
D	75	18	60	90
G	76	12	60	90
F	78	15	60	90
B	78	5	70	85
I	79	14	60	95
C	85	0	75	95

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Another study: The accompanying sheet of five specimens of handwriting was placed before 361 advanced students in a normal school and they were asked to grade each according to a percentage figure and in terms of excellence, good, fair, passed and failure as indicated at the bottom of the sheet. Graph 1 to 5, plate 2, shows the distribution of ratings in terms of excellence, good, etc. It is to be noted that each specimen receives a vote for each classification, even the best specimen is graded failure or non-passed by six and the poorest specimen is ranked excellent by fourteen students. Nineteen normal school and seventeen high school instructors were asked to grade these in a similar manner. The ranking value of each specimen was determined by weighing[1] and the order of merit for each group is:

Specimen No.	361 Normal School Students Ranked	19 Normal School Instructors Ranked	17 High School Instructors Ranked
1	3rd	3rd	3rd
2	4th	4th	5th
3	1st	2nd	2nd
4	2nd	1st	1st
5	5th	5th	4th

To repeat: only one specimen is ranked the same by the three groups. Comparing the judgments of the individuals with the ranking by the total group to which they belonged, the percentage of agreement is:

Number of Agreements	361 Normal School Students	19 Normal School Instructors	17 High School Instructors
0	23%	5%	59%
1	36	37	41
2	18	26	0
3	17	32	0
4	5	0	0
5	1	0	0

In other words, 23 per cent of the 361 adult students, 5 per cent of the normal school faculty and 59 per cent of the secondary school teachers failed to rank any one specimen in the order of merit established by the total judgments of the group to which they belonged. A large percentage of judgments failed to agree with any order of merit.

The distribution of percentage grades for the entire number of judges ranges from 10 to 100. If the judges were consistent and graded these specimens with as much care with the terms as with the per cent valuation, it is fair to suppose that the numerical valuation for any specimen represents the percentage notion for the term used. That is, if one grades specimen 1

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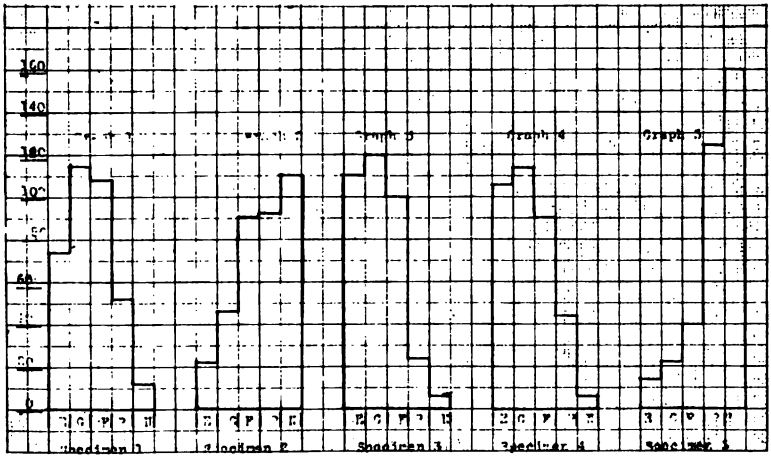
85 per cent and then gives it a term grade of fair, we may say that in this teacher's mind 85 per cent represents fair. Thus we arrive at a numerical valuation for each term used and for each group and can then determine the number of points an estimate will differ from the average of the group. The range of per cents given by the high school teachers is: Excellent, from 90 to 95; good, from 74 to 94; fair, from 70 to 83; passed, from 40 to 80; and failure, from 25 to 70. The average values in per cents for the terms used for each group are:

	Excellent	Good	Fair	Passed	Failure
361 Normal Students	93%	89%	84%	78%	61%
19 Normal Teachers	92%	84%	82%	72%	60%
17 High School Teachers	93%	84%	77%	66%	50%

[1] *Vide* Thorndike, E. L., "Mental and Social Measurements," p. 211.



Grade in Per Cent	Grade in Terms
1	Excellent
2	Good
3	Fair
4	Passed
5	Failure

Again the lack of uniformity is to be noted and also the value of some standard, no matter how weak the standard may be, in bringing about uniformity. The two normal groups approximate each other's values for the reason that some vague standard existed between the instructors and the students. All knew that 60 per cent meant a failure grade and that fair work was usually rated 80 or 85 per cent. Many instructors exempted from finals on a grade of 90 per cent or above and exemption meant more or less a perfect grade. The distribution

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of the average values by the Normal students differs from that of the Normal instructor by 14 points, from that of the high school teachers by 35 points, while the Normal school teachers' average differs from that of the high school teachers by 32 points. The deviation from the percentage valuation by the two groups of teachers is:

	Normal School Teachers						High School Teachers.					
Specimen	1	2	3	4	5	Total	1	2	3	4	5	Total
Value	82%	72%	84%	92%	60%	78%	77%	50%	84%	93%	66%	75%
No. equal	0	1	1	1	10	13	1	4	0	0	0	5
No. higher	6	12	8	5	8	39	5	7	8	1	8	29
No. lower	13	6	10	13	1	43	11	6	9	16	9	51

In order to compare the two groups, the distribution in the total column was converted into percentage figures. The result indicates that 14 per cent of the estimates of the Normal school group just equals the average percentage for that group; that 41 per cent are higher and that 45 per cent are lower; while only 5 per cent of the estimates of the high school group just equals the average figures for that group; 34 per cent are higher and 60 per cent are lower. From this it may be argued that a more equitable decision can be obtained from the Normal faculty as a body than from the high school teachers, since the distribution of the former is about equally placed above and below the average with a fair percentage just equal. The high school group not only shows radical judgments among the individual teachers but the standard is of such a character that 60 per cent are marked lower than the judgment of the group. The fact so often expressed is here shown, i. e., that with any body of teachers the same problem will be variously interpreted and the assumed basis for judgment by the individual teacher is not the assumed basis for the entire group. A further point may be deduced that where the administrative authorities make known from time to time the general distribution of grades, consciously or unconsciously the grading of the individuals approximates more closely the general distribution of the group. The Normal policy was to unify without objective standards the work of the school so that the "Dreaded State Board of Examiners," who examined and graded wholly on a personal judgment basis, might not find great discrepancy in the work of the various teachers. The high school group was composed of students in an advanced pedagogical course who

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taught in nine or more high schools in as many different communities.

Three months after these specimens were first graded, 132 Normal students were again asked to grade them. The results of this grading show that they are less liberal in the range of distribution and that the percentage valuation has dropped to lower values. The agreement with the former judgments is:

Number of Specimen	1	2	3	4	5
Percentage of Agreement	17%	16%	23%	19%	33%

That is, seventeen per cent agree with their former estimate of specimen 1, etc. Thus the fifth specimen, which has been considered the poorest by so many, receives the largest percentage of agreement and yet that agreement is only 33 per cent. Again time has affected the personal judgment. If only one-third of these mature students agree on a specimen obviously so poor, what can be expected of the average teacher who has no standard other than the desire to have his or her teaching appear satisfactory to the administrative authorities?

One more study: The need of some definite system of grading or at least the advisability of some uniformity was made clear in a report sent by the Dean of Applied Industries, Carnegie Institute of Technology, to the members of his faculty. The facts presented were illuminated with graphs and tabulations and the plan of grading adopted by the George Washington University was given some prominence so that some tangible standard would be known to the entire faculty. It was thought that a mere presentation of facts showing the great need for uniformity would be sufficient to convince each member that his personal judgment was of little value and that in order to have uniformity for the distribution of honors he ought to conform to the average of the group or to some supposed standard which the group would adopt. The truth or falsity of this assumption is indicated in the accompanying tabulation.

Before presenting the tabulation, it might be well to indicate roughly the subject matter of the report. Twenty per cent of the 28,257 grades assigned during three years were below passing. Less than 5 per cent were honor rank or the highest grade, while 12 per cent of all grades given to graduates were of the honor rank. An average of 29 per cent of all grades given the night students were below passing, while only 20 per cent of that grade were given to day students. Of all grades assigned by the academic instructors, 51 per cent were below passing,

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while only 25 per cent of grades assigned by the instructors of shop subjects were below passing. The teachers of academic subjects placed 19 per cent of all of their grades above the average or middle "C" grade, while the shop instructors placed 25 per cent of their grades above that point. The discrepancy in the grading of these two classes of instructors suggested that perhaps the school had accepted the motor minded rather than the mentally alert student. In order to satisfy this suggestion, a series of psychological tests was given to determine whether these students were less able to do academic work. The results of these tests given to 183 students representative of the student body indicated that the curve representing their mentality approximated very closely the probability curve for general distribution and that the skewed curve to the lower level of the academic instructor and that to the higher level of the shop instructors were not just curves for the students represented. The study further indicated that a little more than 40 per cent of all grades given by the twenty mathematical instructors were below passing. In English, 34 per cent assigned by the eight instructors were of the same value. Of all grades assigned, the "H" or highest grade was used 40 per cent in printing, 38 per cent in industrial history, 20 per cent in manual training, 18 per cent in telephony, 11 per cent in mechanical drawing, 8 per cent in electric wiring, 7 per cent in bricklaying, and 5 per cent in strength of materials; while in forging, estimates and cost, modeling, pattern-making, principles of design, sheet metal, and stationary engineering not a single per cent of all grades assigned attained the rank of "H." For three years, covering six opportunities of grading, one instructor did not give an "H" grade, another within that same time gave less than one per cent of that grade; while another, with practically the same students, placed over 70 per cent of his grades within the "H" rank and another gave 51 per cent of his the "H" distinction.

From the wide variation in the individual distribution, it seems evident that a greater uniformity was imperative if school honors and class distinctions were to be granted wholly on the scholastic standing as indicated by the personal judgments of the instructors. In fairness to all it might be stated that this report received no comment other than the letter of transmission which I sent to the Dean and which he included in the report. The following tabulation presents the deviation of grades from the suggested standard of the George Washington

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University. The curve of distribution suggested by the George Washington University is that approximately 4 per cent of all grades granted by the instructor be rated as excellent or honor, 24 per cent good, 44 per cent fair, 24 per cent passed and 4 per cent failure.

The effect of this report is seen by comparing the amount of deviation for the first semester before the report was made known and that for the second semester after it was published. Column 1 indicates the instructor by letter, column 2 the type of student, day or night, column 3 the total letter of grades assigned by each instructor for each semester, the next five columns the amount of deviation for each class of grade for each semester, and the last column the total deviation regardless of signs.

DEVIATION FROM A CURVE OF DISTRIBUTION.

Instructors	Day or Night	Total No. Grades		Amount of Deviation. Honor		Merit		Credit		Passed		Failure		Total	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A	D	133	156	+ 4	+ 4	− 7	− 5	− 1	+ 3	− 1	− 6	+ 5	+ 4	18	22
B	D	11	38	− 4	− 1	−15	+ 4	+11	− 7	− 6	+ 7	+14	− 4	50	23
C	N	55	90	+ 1	+ 6	−12	− 6	− 9	− 1	+12	− 6	+ 8	+ 7	42	26
D	D	60	80	− 4	− 2	− 9	− 3	− 6	+14	+13	− 4	+ 6	− 5	38	28
E	N	35	37	+ 7	+ 7	+10	− 3	−21	− 8	+ 5	− 3	− 1	+ 7	44	28
F	D	84	86	− 2	+ 2	− 1	− 4	+ 1	+12	− 5	− 9	+ 7	− 1	16	28
G	D	46	55	+14	+ 9	+ 3	− 6	−20	− 8	−11	− 2	+14	+ 7	62	32
H	D	70	118	+16	+ 9	− 1	− 5	−21	− 5	− 3	− 6	+ 9	+ 7	50	32
I	D	41	62	+14	+14	− 3	− 3	− 4	− 4	− 3	− 9	− 4	+ 2	28	32
J	D	183	139	0	+ 3	−16	+13	−10	+ 1	−40	+ 4	+46	−13	112	34
K	D	103	124	+ 6	+ 9	− 8	−10	+ 8	0	− 5	− 7	− 1	+ 8	28	34
L	D	107	129	− 4	− 3	+ 3	+ 9	+ 4	+ 6	0	−14	− 3	+ 2	14	34
M	D	47	73	− 1	− 2	− 5	−13	−19	− 4	− 4	+12	+29	+ 7	58	38
N	D	49	30	− 4	− 4	− 8	−11	−32	−19	−16	0	− 4	− 4	64	38
O	D	102	116	− 3	− 1	− 4	−11	− 8	− 1	− 3	− 8	− 2	−19	20	40
P	D	34	23	− 1	0	− 4	− 2	− 4	− 9	−15	−11	−16	−18	40	40
Q	D	181	176	− 1	+ 3	− 1	+14	+21	+ 4	−17	−17	− 2	− 4	42	42
R	N	126	111	− 1	+13	− 1	− 2	− 5	+ 8	− 1	−16	− 1	− 4	9	43
S	D	65	43	− 4	− 4	−16	− 3	+44	+18	−20	−15	− 4	+ 4	88	44
T	D	71	62	− 4	− 1	−12	−16	+ 1	+12	+ 2	+10	+13	− 5	32	44
U	D	60	56	− 4	0	+ 3	− 4	+ 2	+23	− 2	−16	+ 1	− 3	12	46
V	N	48	34	− 4	− 7	+17	+12	+ 8	+12	−17	−13	− 4	− 4	50	48
W	D	112	100	− 1	+ 2	−10	−10	+ 3	−14	− 1	+ 4	+ 9	+18	24	48
X	N	66	51	+16	+10	− 5	− 6	+ 1	+14	−17	−17	+ 5	− 1	44	48
Y	D	131	138	− 4	− 3	−12	−13	+ 9	+21	− 6	− 8	+13	+ 3	44	48
Z	N	18	15	− 4	+ 9	− 2	+13	−16	− 1	+ 4	−24	+18	+ 3	44	50
Aa	D	36	57	+16	+12	+23	+16	−11	− 7	−24	−15	− 4	− 2	78	52
Bb	D	105	104	+ 8	− 2	+20	− 8	0	+26	−24	−13	− 4	− 3	56	52
Cc	N	23	17	+18	+ 4	+15	−23	−35	+16	+ 2	+ 7	0	− 4	70	54
Dd	D	28	26	− 4	+16	−10	− 4	+42	+11	−24	−19	− 4	− 4	84	54
Ee	D	140	108	+ 5	− 5	− 3	+ 7	+ 9	+20	−10	−16	− 1	− 6	28	54
Ff	N	55	20	− 4	− 4	+22	+ 6	0	+21	+14	−24	+12	+ 1	52	56
Gg	D	91	94	− 3	− 2	−11	− 9	+26	+24	− 9	−20	− 3	+ 7	52	62
Hh	D	114	92	− 1	− 1	−17	− 5	+42	+36	−21	−17	− 1	− 3	82	62
Ii	N	48	42	+12	+20	+ 2	+12	−18	− 8	0	−20	+ 4	− 4	36	64
Jj	N	32	33	+ 8	− 4	−14	+ 4	− 7	−24	+ 7	0	+ 6	+24	42	66
Kk	D	102	82	− 4	+ 4	−17	− 4	−15	−10	+10	−19	+26	+29	72	66
Ll	N	64	81	+ 7	+11	−10	−14	−18	−22	+ 4	+ 1	+17	+24	56	72
Mm	N	51	22	+ 2	+10	+10	−10	−22	−26	+ 5	+16	+ 5	+10	44	72
Nn	N	70	65	+15	+21	+22	+11	−21	−24	−20	−15	+ 4	+ 7	82	78
Oo	D	77	97	−10	− 4	− 4	−19	+32	+40	−15	−16	− 3	− 1	64	80
Pp	D	53	33	− 2	+11	− 9	+ 4	− 9	−24	+ 2	− 5	+18	+36	40	80
Qq	D	92	83	+ 6	+ 5	+ 8	+16	+ 1	+ 3	−16	+20	− 1	−44	32	88
Rr	N	83	72	− 1	+ 9	+24	+36	− 1	−21	−24	−20	+ 2	− 4	52	90

The tabulation shows that eighteen out of the forty-four instructors considered have a less deviation the second semester

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than the first and while this may be some fruits of the report, mere chance may have had more influence than the report.

Summarizing the three studies one can conclude that:

1. It is unjust to all concerned to award school honors and class distinctions on the personal judgment standard of teachers.
2. Personal judgments in their variation play a very great part in the fluctuation of the student's work. The lap-joint and handwriting were constant factors, yet the grades fluctuated, and this fluctuation is often considered as being due to student ability.
3. Rank placement is a much better indication of progress and is less likely to err than a percentage basis.
4. When the curve of distribution for the entire group is made known from time to time, the individuals approximate more closely this curve.
5. A mere presentation of facts, showing irregularity in grading, is not sufficient to change instructors from the haphazard and easy going methods of expressing personal judgments to a more scientific and exacting method.

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AMBIGUOUS DIRECTIONS.

What the book said: "Pour a little water into the bottle of ammonia gas, and shake, holding the hand over the mouth."

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THE STATUS OF THE SCIENCES IN NORTH CENTRAL HIGH SCHOOLS IN 1916.

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The remarkable growth of the American high school in the past half century has brought with it a number of educational problems which administrators of the public schools must face. Prominent among these problems is the high school science situation. Recent years have seen a number of investigations in the field of high school science, but they have largely been studies of a single subject limited to a small field. So far as the writer is aware, no attempts have been made to make a comparative study of various high school sciences in a large number of high schools.[1]

It was with this purpose in mind that the writer undertook such an investigation in the fall of 1916. The study was made in full appreciation of the shortcomings of the questionnaire method, but the necessary data could not be secured in any other way. The data from which the summaries offered herein were compiled were obtained from replies to a questionnaire sent to the principals of 391 high schools of the North Central Association. One hundred and fifteen replies were received, one hundred and one of which were usable. The remainder of the work was merely the task of subjecting the data obtained to statistical treatment.

The schools were classified into groups according to the high school enrollment, and tabulations were made on that basis. That is, the purpose was to determine the central tendency for the various sciences in the different sized schools, as well as the general movements in all the schools reporting. High schools enrolling less than 100 pupils were known as Group A; those enrolling between 101 and 200 pupils were known as Group B; etc. Group K was composed of all those schools enrolling more than 1,000 pupils.

The nine commonly appearing high school sciences, viz., agriculture, biology, botany, chemistry, general science, physics, physiology, physiography, and zoology were considered from the following standpoints:

1. Frequency of appearance in high school curricula.

[1]Note.—Since writing the above the writer's attention has been called to a study by Prof. Koos of the University of Washington, on the status of all the high school subjects in the high schools of the North Central States. His findings with respect to the high school science situation corroborate our own.

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2. Frequency of requirement of subject for graduation from high school.
3. Relative size of classes in subjects.
4. Length of courses offered.
5. Year in which subjects are offered.
6. Experience, training, sex of teachers of sciences.
7. Library equipment for subject.
8. Laboratory work and equipment.

Table I shows in summarized form the percentages of frequency of appearance of the nine sciences in all sizes of schools reported. Table I should be read as follows: 55.3 per cent of the 101 schools whose reports were used offer agriculture, and 16 per cent of the schools offering it require it for graduation from high school; etc.

TABLE I.

Subject	A	B
Agriculture	55.3%	16.0%
Biology	28.7	13.9
Botany	66.3	11.5
Chemistry	82.1	33.3
General Science	52.4	28.3
Physics	95.0	42.7
Physiography	61.3	12.9
Physiology	46.5	17.02
Zoology	35.6	14.3

A. Percentage of schools replying offering subject.
B. Percentage of schools offering subject requiring it for graduation.

It is evident that this table fails to take into account the variation in frequency of appearance of the subjects from group to group. For example, agriculture, which appears with a high percentage of frequency in the medium sized schools, appears with a low frequency in the larger schools. From this table, however, we are able to see at a glance the relative importance of the nine sciences from the point of view of frequency of appearance. On this basis the subjects rank as follows: Physics, chemistry, botany, physiography, agriculture, general science, physiology, zoology, and biology.

TABLE II.

Subject.	Year Offered.	Med. Class for Year.	Med. Class Enrollment.	S.	I.	R.	Per Cent.	Rank.
Agriculture	3	42	24		9		57.0	4
Biology	2	59	18		8		30.5	9
Botany	2	59	41		25		69.9	3
Chemistry	3	42	34		12		81.0	1
General Science	1	88	45		19		51.0	5
Physics	4	33	25		15		79.0	2
Physiography	1	88	36		32		40.5	6
Physiology	1	88	29		19		33.0	8
Zoology	2	59	22		22		37.0	7

Table II shows for each subject the year in which it is offered, the median for the total size of the class for the year in which

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it is offered, the median enrollment in the subject with the semi-inter-quartile-range given, the percentage that the median enrollment in the subject is of the total size of the class for the year in which it is offered, and the rank of the subjects on this basis. Table IV of this paper offers the basis for determining the year in which the subjects are offered. The median sizes of first, second, third and fourth year classes was determined from percentages given on page 487 of the Commissioner of Education's Report for 1916. The average percentage for each of the four high school classes for the North Central States was found, and the median class found on the basis of the median enrollment of all the schools reporting for this study, which was 222 pupils. The semi-inter-quartile-range is found by taking one-half the difference between the first and third quartiles of the array, and means the distance on either side of the median it will be necessary to go in order to include 50 per cent of the cases. Table II is read as follows: Agriculture is most often offered in the third year of the high school course. Over 50 per cent of the class enrollments fall between 15 and 33 pupils. The median size of the third year high school class is 42 pupils. Fifty-seven per cent of the median third year high school class is enrolled in agriculture, and on this basis agriculture ranks fourth among the nine sciences; etc.

There are certain quite well defined tendencies in the matter of the length of the science courses. Some, such as zoology, and physiology, are obviously one semester courses; others, as botany, chemistry, and physics are just as definitely classified as two semester courses. Table III shows this situation clearly in terms of percentages.

TABLE III.

Subjects	Semesters One	Two	Three	Four	Six	Eight
Agriculture	30.8%	49.8%	1.8%	9.1%	1.8%	7.3%
Biology	25.0	75.0				
Botany	53.7	44.8	1.5			
Chemistry	1.2	95.1	1.2			
General Science	35.8	64.2				
Physics	2.2	95.6	2.2			
Physiography	57.9	42.1				
Physiology	80.4	19.6				
Zoology	80.0	17.1				

This table is to read as follows: 30.8 per cent of the 101 schools reporting offering agriculture offer it for one semester; 49.8 per cent offer it two semesters; 1.8 per cent offer it three semesters; 9.1 per cent offer it four semesters; etc.

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TABLE IV.

Subjects	Year			
	First	Second	Third	Fourth
Agriculture	17.7%	26.2%	33.3%	21.4%
Biology	16.6	76.7	6.6	
Botany	26.9	55.1	12.9	5.1
Chemistry	1.1	2.2	49.1	47.6
General Science	96.2	3.7		
Physics	.9	1.8	38.4	57.8
Physiography	59.1	23.9	5.6	11.2
Physiology	43.1	15.7	29.4	11.8
Zoology	6.8	68.2	18.1	6.8

From Table IV it is evident that, with the possible exception of general science, the year in which the sciences are offered is not well fixed in practice. Agriculture is almost equally divided between the four years; biology is quite definitely located in the second; chemistry and physics are evenly divided between the third and fourth years, etc.

From the data shown in Table V it appears that in general male teachers of the sciences are more popular than female teachers. In only two cases of the nine sciences listed do we find the percentage of male teachers of the subject falling below 50 per cent, and in only one subject, zoology, do we find the percentage of female teachers exceeding the percentage of male teachers. For the female teachers the median is 43.3 per cent, for the male teachers the median percentage is 60.0 per cent; showing a decided tendency in favor of the latter.

TABLE V.

Subjects	Percentage Teachers		Avg. Yrs. Experience		Sem. Hrs. Training	
	M.	F.	M.	F.	M.	F.
Agriculture	91.1%	7.1%	3.2	2.8	10	24
Biology	55.6	40.1	3.0	7.0	14	30
Botany	51.4	47.1	7.5	6.8	14	16
Chemistry	88.6	11.4	6.6	7.0	21	15
General Science	74.0	20.8	2.4	2.4	12	
Physics	89.9	11.1	8.0	6.6	17	15
Physiography	55.4	41.5	4.1	5.8	10	12
Physiology	48.9	44.8	3.7	4.8	8	3.5
Zoology	38.2	50.0	4.8	5.7	9	19

The average years of experience in teaching the science subjects ranges, for men from 2.4 years for general science to 8 years for physics. The median years experience for men is 3.5 years. For women, the lower limit is the same as for men for general science, but goes up to only 7.0 years for both biology and chemistry. The median number of years experience for women is 6 years. Along with this may be noted the fact that the median number of semester hours college preparation in the subjects for all female teachers of the sciences listed is 15.5 hours, as

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contrasted with 12 hours, the median for male science teachers. It is thus apparent that while male teachers are found in the science positions with a slightly greater frequency, the female teachers are better prepared to teach the subjects, if college training is an indication of preparation to teach a subject. Female teachers are also more experienced in teaching science, or at least remain in that field longer than do male teachers.

TABLE VI.

Subjects	Median Value	Semi-inter-quartile-range
Agriculture	$27.80	$10.50
Biology	15.00	15.00
Botany	23.50	26.00
Chemistry	28.50	24.00
General Science	12.00	9.00
Physics	26.65	30.00
Physiography	18.00	7.00
Physiology	9.00	7.00
Zoology	32.00	51.00

Library equipment in the special science subjects is, unfortunately, not very extensive in the schools reporting for this study. Because of the extremely wide range in a number of the cases the medians given appear to be of questionable value, but, when limited by the semi-inter-quartile range, do serve to give us the central tendency with respect to library equipment. The sciences having libraries valued at more than the median for all libraries are: agriculture, botany, chemistry, physics, and zoology. The remaining sciences, biology, general science, physiography, and physiology, have values lying below the medians for all subjects.

The number of volumes in the special libraries varies from 10 to 25. The median number is 17 volumes. The following subjects have libraries larger than the median: agriculture, botany, chemistry, physiography, and zoology. The remaining four sciences, biology, general science, physics, and physiology, have libraries smaller than the median.

TABLE VII.

Subjects	Median Value of Lab. Equipment	Semi-inter-quartile-range
Agriculture	$205.00	$ 94.00
Biology	400.00	330.00
Botany	270.00	62.50
Chemistry	550.00	500.00
General Science	120.00	225.00
Physics	950.00	500.00
Physiography	100.00	132.00
Physiology	75.00	55.00
Zoology	125.00	262.50

The median values of laboratory equipment for the sciences

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range from $55.00 for physiology up to $900.00 for physics. In a few cases the semi-inter-quartile range is quite wide, however, in the majority of cases the medians are quite reliable. If they are reliable they are certainly significant of the status of the subjects. Ranked according to the values of the laboratory equipment the subjects are as follows: physics, chemistry, biology, agriculture, zoology, general science, physiography, and physiology. The median value of all laboratory equipment in all subjects reported is $200.00 with a median deviation of $100.00.

TABLE VIII.

Subjects	Median No. of Lab. Expts. Attempted	Semi-inter-quartile-range
Agriculture	46	16
Biology	38	15
Botany	31	11
Chemistry	60	5
General Science	33	14
Physics	45	5
Physiography	15	8
Physiology	18	5
Zoology	24	11

The amount of laboratory work in the different sciences is undoubtedly indicative of the status and importance of the subject, but just to what extent it is indicative is hard to determine. In general, it appears that the sciences that have ranked high from other points of view, also rank high when considered from this standpoint. It is evident that we are taking a liberty when we use the term "experiment" as a unit, for certainly an "experiment" in chemistry is not necessarily the equal of an "experiment" in physics or in zoology. However, the median number of experiments attempted for each science is shown in the above table. Ranked on this basis the sciences are as follows: chemistry, agriculture, physics, biology, general science, botany, zoology, physiology, and physiography. Those sciences above general science in the list are either on or above the median for all.

The attempt to determine the final ranking of the sciences seems best made by comparing the various subjects from a number of points of view from which they have been treated in this paper. Table IX shows the results of such an attempt.

TABLE IX.

Subjects	I	II	III	IV	V	VI	Total	Final
Agriculture	5	5	4	3	5	2	24	3
Biology	9	7	9	7	3	4	39	7
Botany	3	9	3	5	4	6	30	4

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Chemistry	2	2	1	2	2	1	10	1
General Science	6	3	5	8	7	5	34	5
Physics	1	1	2	4	1	3	12	2
Physiography	4	8	6	6	8	9	41	8
Physiology	7	4	8	9	9	8	45	9
Zoology	8	6	7	1	6	7	35	6

I. Rank of subjects in percentage of frequency of appearance.
II. Rank of subjects in percentage of frequency of requirement for graduation from high school.
III. Rank of subjects in terms of percentages of pupils in high school classes (year) enrolled in subjects.
IV. Rank of subjects in terms of the value of library equipment.
V. Rank of subjects in terms of laboratory equipment.
VI. Rank of subjects in terms of number of laboratory experiments attempted.

The six ranks used in this table were taken directly from the preceding tables and represent the points of view from which it seemed legitimate to compare the subjects. It is obvious that the data included in Tables III and IV were not usable for this purpose. It is just as obvious that to rank the sciences on the basis of the percentage of male teachers employed would be of slight value, for the mere inclusion of the rank of the sciences on the basis of the percentage of female teachers employed would make it possible to manipulate the final rank at will, so such variable data were not included in the attempt to determine the final rank of the sciences. The fact that there is a high correlation between the value of libraries and the number of volumes in them made it necessary to include only one factor on that point.

The final rank of the high school sciences on the basis of the six points given above is as follows:

1. Chemistry.
2. Physics.
3. Agriculture.
4. Botany.
5. General Science.
6. Zoology.
7. Biology.
8. Physiography.
9. Physiology.

The following table of intercorrelation is given merely to show the relation of each factor used in determining the rank to every other factor and to the final rank.

TABLE X.

Intercorrelations—Spearman

Rank in	I	II	III	IV	V	VI	Final
I		.25	.7	.18	.4	.18	.4
II			.25	.03	.33	.25	.4
III				.33	.4	.48	.7
IV					.33	.25	.48
V						.55	.63
VI							.63

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A STUDY OF THE ATTAINMENTS OF HIGH SCHOOL PUPILS IN FIRST YEAR CHEMISTRY.[1]

By J. Carleton Bell,

Brooklyn, New York, Training School for Teachers.

Introduction—Experimental Studies of the Results of Teaching.

There is a growing realization of the need for careful and accurate studies of the methods and results of teaching. In all lines it is recognized that too much dependence has been placed on inspiration and faith, and too little scrutiny has been given to results. It is especially incumbent upon teachers of science to make an application of the experimental methods which have been their boast in nature studies to the problem of determining the results of their own teaching.

Early attempts at measuring the attainments of pupils in school subjects were confined to the elementary branches. In arithmetic Rice in 1902 devised pioneer tests in the endeavor to determine whether the large amount of time devoted to the subject in some schools gave commensurate returns in increased performance. He concluded that it did not. Stone followed in 1908 with a more carefully analyzed series of tests in fundamentals and problems, and confined his attention to the study of the arithmetical abilities of sixth-grade pupils. Courtis in 1910 and 1914 devised two series of tests for measuring arithmetical attainments, and through his Bureau of Cooperative Research has secured records from thousands of children. Finally, Woody in 1916 derived a scale for measuring the achievements of pupils in the fundamental arithmetical operations.

In spelling, the studies of Rice, Cornman, and Wallin opened up the field and prepared the way for the more accurate investigations of Buckingham, who determined statistically the relative spelling difficulty of 180 words, and of Ayres, who selected the 1,000 words most commonly used in writing and arranged them in a scale of twenty-six equal steps of spelling difficulty. In handwriting, we have the Thorndike and the Ayres scales, the Freeman standard measurements, and the Gray score card. Many cities (notably, New York) are now constructing their own scales for the measurement of handwriting. In drawing, there is the Thorndike scale, with the Childs extension, and the

[1]Read before the Chemistry Section of the Central Association at Columbus, Ohio, December 1, 1917.

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Rugg scale for free-hand lettering. Several studies have been made in geography, and in reading we have the Starch tests, the Thorndike scales, the Brown test, the Kansas tests, and the Gray scales for the measurement of oral and silent reading. From this hasty survey it will be seen that measurements of the attainments of pupils in elementary subjects are multiplying apace, and it may be confidently stated that they are already having their effect on both the subject matter and the methods of elementary school work.

When we turn to the high school field we find less to chronicle. In algebra, Monroe, Childs, and Rugg have constructed promising tests for the work of the first year; in Latin, Hanus carried on a preliminary investigation of vocabulary, H. A. Brown has much unpublished material on translation from Latin into English, and Henmon has published in the *Journal of Educational Psychology* carefully constructed scales for the measurement of Latin vocabulary and Latin translation; in geometry, Stockard and Bell studied the responses of 372 pupils to a representative list of questions; in history, Bell and McCollum investigated the attainments of 1,500 pupils in United States history, and Sackett has proposed a scale for the ancient period; and in zoology Gilbert reported an experiment on methods of teaching the subject. Mann has for some time been engaged in an elaborate investigation of engineering education, and has devised some ingenious tests for students of physics, but so far as the writer knows has published nothing on the subject. Mayman made an interesting experimental study of the relative values of the textbook, lecture, and laboratory methods of teaching physics to seventh-and eighth-grade boys.

The work of Gilbert, as the only published experimental investigation in the teaching of any of the natural sciences to secondary school pupils, is worthy of somewhat more extended notice. Gilbert's problem was to ascertain whether the pure science or the applied science method of attack gave better results in teaching elementary zoology to high school students. He divided his class of thirty-two pupils (how we are not told) into two almost equal sections. Each of these sections was given the same subject matter, but in Section A emphasis was laid on analysis and description, after the approved fashion in elementary zoology, while in Section B, in addition to the strictly zoological study, stress was placed on the economic significance

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of the animals considered. At the end of the term both sections were given the same test, which was constructed from the point of view of pure zoology. The applied science section made slightly the better showing. In tests of ability in experimentation and interpretation the applied science section was distinctly superior. The author concludes that the results of the experiment favor the applied science rather than the pure science method for high school pupils.

The only consideration thus far given, within the knowledge of the writer, to a scientific study of the teaching of chemistry is in an article by Ellwood B. Spear, entitled, "Problems in the Experimental Pedagogy of Chemistry." Spear assumes that the chief value in teaching chemistry to high school pupils lies in the general mental training it affords, and suggests problems to determine to what extent the general traits of manipulation, observation, correlation of ideas, logical reasoning, imagination, and the spirit of investigation are developed by the study of chemistry. But modern psychology bids us be very chary about accepting the existence of such broad general faculties. It is open to question whether there is any such thing as a general power of observation. Certainly, improvement in the observation of chemical reactions would scarcely be expected to improve one's observation of fine paintings, or of the fall of the cards in a game of whist. Before we are ready to investigate the *general* mental improvement which results from the study of chemistry, we need to know more about the improvement of pupils in chemistry thinking itself.

The Present Study.

A really adequate study of the attainments of pupils in chemistry would involve a series of tests to determine the natural intellectual abilities of each pupil before taking up the subject; a careful study of the previous training of each pupil; an exact record of the work of the course, including the topics taken up, the time devoted to each, the methods of presentation and study, the attitude of the pupil toward the work, and the personal influence of the instructor; a series of reliable tests at the end of the course to show the pupil's mastery of the subject; another series of tests after the lapse of a considerable time to indicate how much of the subject was retained; and a test of the readiness with which this knowledge could be applied to other chemical situations. The present study makes no pretense at any such completeness. It is a preliminary, tenta-

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tive investigation, undertaken primarily to find out what Texas high schools were doing in chemistry, and what variations schools and individual pupils would show in response to the same set of questions. Incidentally, it was thought that the results might throw some light on the relative difficulty of various aspects of chemistry.

The first task was the selection of a list of questions that would be fairly representative of the field of first-year chemistry. A more objective method would have been to draw up a list of 200 or 300 questions covering all phases of elementary chemistry, and to submit these to experienced chemistry teachers in different parts of the country with the request that they arrange them in the order of their importance. Such a procedure, however, would have required much time, and in the present instance it was thought advisable to act at once. After a careful study of the leading texts in elementary chemistry and an analysis of their contents, twenty-five questions were chosen as covering the more important and more generally considered topics of chemistry.[2]

The aim in the formulation of these questions was to select topics that were basic for elementary chemistry, to phrase the questions so that they could be answered briefly, and to call for such answers as would be either right or wrong. When the results came to be evaluated, however, a more satisfactory scoring was found to be one credit for answers approximately correct, one-half credit for those only partially correct, and zero for those quite beside the mark. At the top of the page the pupil was asked to indicate in appropriate blank spaces his name, the school, the date, the amount of chemistry instruction he had had, and the time when this work was taken. The questions were as follows:

1. What chemicals are liberated in electrolysis of water?
2. What gas is given off by the action of yeast in bread dough?
3. Name two chemicals used in making oxygen.
4. Express in cubic centimeters one litre.
5. Name two substances used in making hydrogen.
6. Define oxidation.
7. Define reduction.
8. Name four processes of purifying water.
9. What is a deliquescent substance?
10. Name two gases either of which might be used to bleach cloth or flowers.
11. Name two very common organic acids.

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[2]For this work the writer desires to express his obligation to Mr. R. G. Upton, an experienced teacher, who was at that time assistant in education in the University of Texas.

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12. Name two chemical compounds used in making common salt.
13. Write the reaction for sulphuric acid on potassium hydroxide.
14. Name the two most abundant elements in the atmosphere.
15. Name two commercial sources of ammonia.
16. Is air a chemical or physical mixture?
17. Why does ammonia water always feel cold when it comes in contact with the hands?
18. Name substances used to make aqua regia.
19. Name four basic hydroxides.
20. Name the commercial uses of the nitrates.
21. What are the properties of carbon bisulphide?
22. Give chemical name of $CaSO_4$....., H_2S....., Na_2SO_3.....
23. What is the valence of H....., of O....., of Ca....., of SO_4.....
24. Name the members of the chlorine group.
25. How many grams of water are formed by the combustion of 10 grams of hydrogen in the air? (Work on this paper.)

Returns were received from chemistry classes in 16 of the leading high schools of Texas. They included papers from 401 pupils. In 14 of these schools the pupils (337 in number) had studied chemistry for eight months. These results were grouped together and form the chief basis for the present discussion. In one school the study had been carried on only three months, while in another school results were obtained from two classes, one of which had studied chemistry for three months, and the other, an advanced class, had studied the subject for twelve months. The number of pupils in these classes ranged from 10 to 50, with an average of 24.

Unfortunately, no data were secured as to the method of conducting the work in chemistry, the textbooks used, the number of sections in a class, the number of recitations per week, the amount and character of laboratory work, the extent of laboratory equipment, or the topics emphasized in the course. The scores, therefore, have to stand as bare results, with no supplementary material for interpretation.

The Results.

This is not the place for the presentation of statistical tables. These will be found in the special science number of the *Journal of Educational Psychology*, published in April, 1918. Here it must suffice to indicate the general features of the returns. The scores were tabulated to show the response of each pupil to each question. The total score of each pupil was determined and expressed in per cents of a perfect score. The average of these per cents was taken as the index of the school, and the average of these indices gave the status of the entire group. Further, the percentage of correct responses made by each school to each question was computed, and these were

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combined to show the relative familiarity of each question. The results from the 14 schools whose pupils had studied chemistry for eight months will first be considered. The average scores for these schools range from Lockhart (14 pupils), 81 per cent; Brownwood (18 pupils), 75 per cent; Coleman (15 pupils), 69 per cent; and Fort Worth (50 pupils), 69 per cent; to Uvalde (10 pupils), 45 per cent; Garland (16 pupils), 45 per cent; and San Marcos (28 pupils), 36 per cent. The average for the entire group of schools was 59 per cent. It will be noted that the ratio of the extremes is well below 1 to 2, and that size of school seems to have no connection with grade of performance. The Lockhart school had 100 per cent correct on six questions, 75 per cent or better on sixteen questions, and the lowest question received 29 per cent. In the San Marcos school the highest score on a question was 86 per cent, the next highest was 70 per cent, seven questions received scores of less than 10 per cent, and two questions had 0 per cent. Thus the difference between the two schools was a uniform one and did not depend on the responses to a few questions.

The highest individual scores were made by two boys in the Dallas high school (46 pupils). Their scores were 100 per cent and 98 per cent, although the average of that school was only 63 per cent. The lowest scores were made by three boys in the San Marcos high school, 16 per cent, 18 per cent, and 18 per cent. The Beeville high school (23 pupils) showed the greatest extremes, ranging from 90 per cent to 18 per cent (boys in both cases), with an average of 56 per cent. Denton high school (18 pupils) had one boy who got 94 per cent, while two Lockhart boys received 94 per cent and 92 per cent respectively. In almost all the high schools the range of scores was very wide, running usually from the thirties to the eighties. Exceptions to this were Lockhart, where the range was 94 per cent to 66 per cent; Brownwood, 88 per cent to 66 per cent (showing the least variation of all), El Paso (21 pupils), 84 per cent to 46 per cent; Mexia (21 pupils), 70 per cent to 28 per cent; Garland, 70 per cent to 24 per cent; and San Marcos, 62 per cent to 16 per cent.

In addition to the 14 schools whose pupils had had eight months of chemistry, reports were received from 36 pupils in the San Antonio high school, who with only three months' instruction made an average score of 58 per cent, range 86 per cent to 30 per cent. In the Galveston high school were two

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classes of 14 pupils each. The advanced class had had twelve months of chemistry, and made an average score of 76 per cent, range 86 per cent to 50 per cent. The elementary class had had only three months of chemistry and its average was 36 per cent, range 54 per cent to 20 per cent.

From these figures it is obvious that there are striking differences in the work done by the various schools. San Antonio probably makes the best showing, since in three months' time an average score is obtained which is within one point of the average for all of the eight-months' pupils. In the same time of three months, Galveston only does as well as the poorest of the eight-months' schools, and in twelve months it does not come up to the best of the eight-months' group. The figures are to be commended to the principals and teachers of these schools for a careful examination of the question whether their time is being used to the best possible advantage.

A special tabulation of the results from boys and girls was made for each school. Of the entire 401 pupils, 199 were boys and 202 were girls. On the whole the numbers were fairly equal in the several schools, the greatest discrepancies being found in Coleman (3 boys and 12 girls), and Denton (14 boys and 4 girls). As already pointed out, all the highest and lowest scores were made by boys, the girls' scores occupying an intermediate position. On the average the boys were distinctly superior to the girls, the boys scoring 62 per cent, the girls 56 per cent. This superiority of the boys was found in 13 out of the 17 classes, and is thus quite uniform.

Not only were the individual and class scores on the entire test computed, but the percentage of correct responses was determined for each school on each question. A detailed discussion of these results would lead us too far for the present occasion. We may note that on the basis of the 14 schools in our main group, Question 1 (electrolysis of water) was the most familiar, with an average of 93 per cent. Next in order come Question 2 (yeast in bread) with 90 per cent, Question 24 (the chlorine group) with 85 per cent, Question 5 (making hydrogen) and Question 19 (basic hydroxides) with 77 per cent each, Question 14 (elements in atmosphere) with 75 per cent, Question 10 (bleaching gases) with 71 per cent, and Question 23 (valence of H, O, Ca, and SO_4) with 70 per cent. It is interesting to note here that the composition of water and the action of yeast are almost equally well known, that there is a distinct drop to the

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chlorine group, and a still greater drop to the basic hydroxides, and that the responses to the other questions fall fairly close together.

On the other hand, the least known was Question 15 (commercial sources of ammonia) with 20 per cent, followed by Question 21 (properties of carbon bisulphide) with 22 per cent, Question 25 (amount of water from the combustion of 10 grams of hydrogen in the air) with 28 per cent, Question 20 (commercial uses of nitrates) with 33 per cent, Question 17 (why does ammonia feel cold) with 35 per cent, Question 9 (deliquescent substance) and Question 12 (compounds used in making common salt) with 50 per cent each, and Question 11 (two common organic acids) with 54 per cent. The gap here between the first five and the last three (35 per cent to 50 per cent) is striking. The percentages for the remaining nine questions are grouped about the average, 59 per cent. It is interesting to observe that Question 3 (two chemicals used in making oxygen), Question 4 (number of cubic centimeters in one liter), Question 6 (oxidation), Question 7 (reduction), Question 8 (four processes for purifying water), Question 18 (substances used in making aqua regia), and Question 22 (chemical names of $CaSO_4$, H_2S, and Na_2SO_3) lie within 5 per cent of each other (58 per cent to 63 per cent).

It is obvious that the present study is a preliminary and local one. It justifies the contention, however, that such studies, amplified and extended, would contribute greatly to the teaching of chemistry. They would afford a means of comparing with some degree of objectivity the work done in different schools. They would soon furnish material for the construction of a scale in chemistry by which it would be possible to determine quickly and accurately the extent of any pupil's attainments in the subject. The prosecution of such studies is urgently demanded of progressive superintendents, principals, and high school teachers of chemistry in this country.

The special campaigns in the South for the increased production of foodstuffs through the extension forces resulted in a marked increase in the planting of corn, soy beans, velvet beans, cow-peas, peanuts, sweet potatoes, Irish potatoes, and other food crops. The corn crop in the fifteen Southern States was 964,504,000 bushels, or more than a fourth of the whole crop of the United States.

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THE GRAPHICAL SOLUTION OF PROBLEMS.

By Paul H. Geiger,
Ann Arbor, Mich.

In the November, 1917, number of School Science and Mathematics appears a paper, entitled, "Two Uses for Graphs." The first part of this article is concerned with the equation used in solving elementary problems about lenses and mirrors, and the author after presenting a graph of that equation shows how to obtain the approximate numerical answers to typical problems. The graphical method thus set forth has certain pedagogical advantages, in that the subject material is clearly and simply displayed. But the numerical results may be obtained, without calculation, by other methods which are sufficiently general to warrant their value and interest. They were brought to the author's attention by Mr. Herbert Bell. The first is an extension of the idea of the slide rule. The second is a very simple example of the straight line nomogram.

In an ordinary slide rule the addition of logarithms is facilitated by two parallel and similar scales which, when they are properly displaced, give a product, just as a sum may be obtained by two ordinary yardsticks. The essential feature of the instrument is that while the ordinary numbers appear along the scales, the distance out to them is proportional, not to the number, but to its logarithm. Such a rule does not help us much with the equation,

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}.$$

But if the scale were so constructed that the distance from

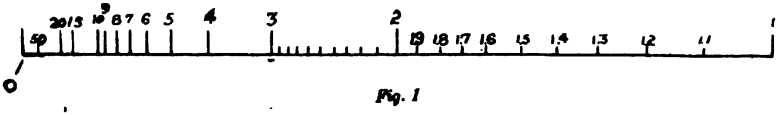

Fig. 1

the origin to any number was proportional to the reciprocal of that number, then two such scales, side by side, would solve a problem of our particular class, just as the ordinary rule gives us a product. Such a scale appears in Figure 1. With a pair of dividers, problems may be solved with this scale alone. For, supposing p is 6 and q is $+2$, we can with the dividers add the reciprocal of 6 to that of 2, giving the reciprocal of 3/2, which is f. Two such scales, side by side, would be operated just as the ordinary slide rule. The scale may be constructed by actual

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computation and measurement, but more simply by projection as is shown in Figure 2. Here the scale of reciprocals appears along AB, natural numbers being set down along CD, and O being the center from which lines are drawn.

Evidently, if Dr. Sleator had laid off scales of reciprocals along his axis and then plotted his curve, it would have been a straight line. Evidently, also, the method is not limited in its application to this one type of problem, but suitable scales may be constructed for any equation expressing an additive relation between simple functions. In case the equation to be solved contains a product or a quotient, one obtains by passing to logarithms a new equation which contains an algebraic sum, thereby permitting suitable scales to be constructed.

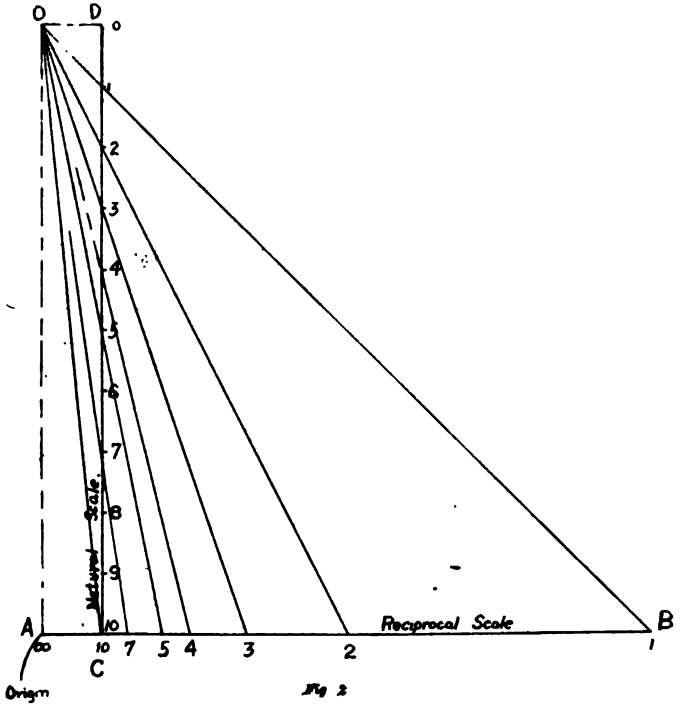

Fig 2

The second method is that of the straight line nomogram. No attempt will be made to give the theory of the nomogram, only a single application which, though originally obtained by using the general method of the nomogram, is so simple that it can be understood without any knowledge of the theory.

The formula,

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$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

may be written

$$\frac{1/p+1/q}{2}=\frac{1}{2f} \qquad \text{(equation B).}$$

On two parallel straight lines EB and E′B′ (Figure 3) are laid off scales of reciprocals as explained under the first method, with the exception that the distances are laid off in both directions from the origins O and O′ instead of in one direction only. Let AC be a line midway between EB and E′B′ and parallel to them. Now if p and q are known we may connect point P (Figure 3) on EB (where the distance OP represents the reciprocal of p) with point Q on line E′B′ (where the distance O′Q corresponds to the value of the reciprocal of q) by a straight line PQ. The distance FD between the intersection of this line with AC and the origin then represents the average length of AC, OP and O′Q, which in mathematical terms is

$$\frac{1/p+1/q}{2}.$$

This by equation B is equal to $1/2f$, so if we lay off on line AC scales similar to those on EB and E′B′ but with the unit only one-half as great, we may read directly the solution. Letting EB be the p axis, AC the f axis, and E′B′ the q axis, we can find either p, q, or f when the other two are given. This is done by laying a straight edge across the two known points on their

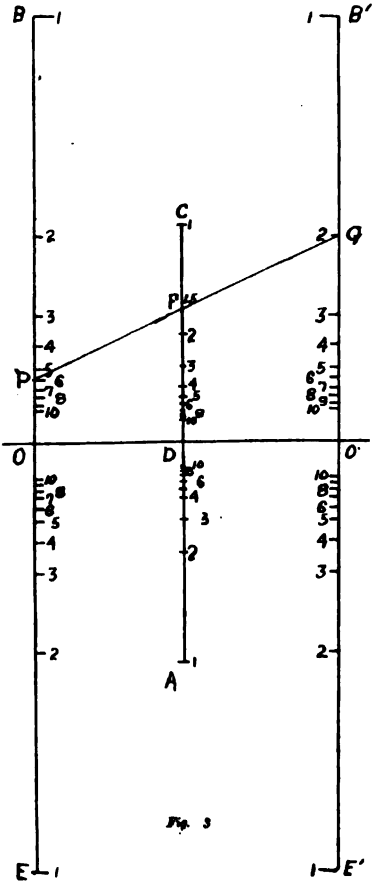

Fig. 3

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corresponding axes and reading the unknown value on the remaining axis. When values are negative, the distances are to be measured below (or to the left of, in case the lines are horizontal) the line OO'.

It is evident that the use of these methods would be extremely limited in case only problems having values which are shown on the scale, can be solved. However, in the calculations we may disregard the decimal point and therefore our scales will apply to any values. The location of the decimal point in the answer is usually obvious; if not it may be determined by easy approximations, as it is determined when the ordinary form of slide rule is used.

The accuracy of these methods is the same as that of an ordinary slide rule. With scales a foot long, results accurate to three significant figures may be obtained; with longer scales the accuracy can be made as great as we may desire.

DAYLIGHT SAVING IN THE UNITED STATES.

By W. M. Gregory,

Teachers College, Cleveland, Ohio.

The geography class will find much material for discussion in the provisions of the Daylight Saving Act which has recently been passed by Congress and signed by the President. The student will quickly perceive that this bill is a national affair, and also that a legal status is given the various standard time belts of the United States and Alaska.

Daylight saving, in a nutshell, is to advance the standard time one hour during a period of five months every year, beginning at 2 o'clock a. m. of the last Sunday in March, and retarding one hour beginning at 2 o'clock a. m. of the last Sunday in October.

There is no suggestion that hours of work be lengthened or shortened. The shortening of the old-time work day of "sun-up to sunset" to the present day of ten hours or eight hours, has resulted in a waste of the morning sunlight hours in the summer months. On a June day the sun rises at 4 a. m. and we start work at 8 a. m. Thus we sleep through hours of sunlight in the morning and have our period of recreation at the close of the day in artificial light. We waste the daylight and use the artificial light and heat which could easily be conserved if this measure became a law.

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The practical value in the conservation of daylight has been fully established where this plan is in operation in Austria, Denmark, France, England, Italy, Holland, Norway, Portugal, and Sweden.

If the student will plat the time of sunrise and sunset for his locality for the entire year, he will readily see how the daylight is thrown away and the artificial light substituted. The Nautical Almanac will give all the necessary data for such a graph. Let the student figure the saving in the electric light bill in his family and city. Careful estimates give $40,000,000 as the amount to be saved in this country in a single year by this plan. France is believed to have saved $10,000,000 each year by this plan, and England about $12,000,000. There is not much but the inertia of tradition to be urged against daylight saving.

The entire provisions of the Daylight Saving Act are to be found in the following paragraphs. From a reading of this act and the graph of daylight and night, have the pupil explain the reason for the change of time in March and October.

THE DAYLIGHT SAVING ACT.

To Save Daylight and to Provide Standard Time for the United States.

Section 1. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That, for the purpose of establishing the standard time of the United States, the territory of continental United States shall be divided into five zones in the manner hereinafter provided. The standard time of the first zone shall be based on the mean astronomical time of the seventy-fifth degree of longitude west from Greenwich; that of the second zone on the ninetieth degree; that of the third zone on the one hundred and fifth degree; that of the fourth zone on the one hundred and twentieth degree; and that of the fifth zone, which shall include only Alaska, on the one hundred and fiftieth degree. That the limits of each zone shall be defined by an order of the Interstate Commerce Commission, having regard for the convenience of commerce and the existing junction points and division points of common carriers engaged in commerce between the several states and with foreign nations, and such order may be modified from time to time.

Section 2. That within the respective zones created under the authority hereof the standard time of the zone shall govern the movement of all common carriers engaged in commerce between the several states or between a state and any of the

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territories of the United States, or between a state or the territory of Alaska and any of the insular possessions of the United States or any foreign country. In all statutes, orders, rules, and regulations relating to the time of performance of any act by any officer or department of the United States, whether in the legislative, executive, or judicial branches of the Government, or relating to the time within which any rights shall accrue or determine, or within which any act shall or shall not be performed by any person subject to the jurisdiction of the United States, it shall be understood and intended that the time shall be the United States standard time of the zone within which the act is to be performed.

Section 3. That at two o'clock antemeridian of the last Sunday in *March* of each year the standard time of each zone shall be advanced one hour, and at two o'clock antemeridian of the last Sunday in *October* in each year the standard time of each zone shall, by the retarding of one hour, be returned to the mean astronomical time of the degree of longitude governing said zone, so that between the last Sunday in *March* at two o'clock antemeridian and the last Sunday in *October* at two o'clock antemeridian in each year the standard time in each zone shall be one hour in advance of the mean astronomical time of the degree of longitude governing each zone, respectively.

Section 4. That the standard time of the first zone shall be known and designated as United States Standard Eastern Time; that of the second zone shall be known and designated as United States Standard Central Time; that of the third zone shall be known and designated as United States Standard Mountain Time; that of the fourth zone shall be known and designated as United States Standard Pacific Time; and that of the fifth zone shall be known and designated as United States Standard Alaska Time.

Section 5. That all acts and parts of acts in conflict herewith are hereby repealed.

GARDEN INCREASE ESTIMATED TO BE AT LEAST TWO HUNDRED PER CENT.

The home-garden campaign of last spring and summer, part of the effort to increase the nation's supply of war-time food, stimulated, it is estimated, the planting of from two hundred to three hundred per cent more gardens than ever before had produced food in the United States in one season, according to the annual report of the Secretary of Agriculture, David F. Houston. This was particularly true in the South, where the work was a logical development of the "safe farming" program which has been advocated for several years.

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RESEARCH IN BIOLOGY.

Conducted by Homer C. Sampson.

Ohio State University, Columbus.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to Dr. Homer C. Sampson, Department of Zoology, Ohio State University, Columbus, Ohio.

THE RELATION OF ECOLOGY TO HIGH SCHOOL BIOLOGY.

By Morris M. Wells,

The University of Chicago.

The problems relating to the teaching of biology in the high school are obvious to those who have attempted the task, and it will not be necessary for me to enumerate them in detail at this time. In general they are problems which may be grouped into two classes, namely, problems pertaining to the organization of the course, and those having to do with the securing of sufficient and suitable material for the class and laboratory work.

These two general groups of problems, which teachers of biology are attempting to solve everywhere are not peculiar to the subject of biology, but are characteristic of all the laboratory sciences. However, I do not believe that the high school curriculum contains any subject, the presentation of which is beset with greater difficulties, than those to be met with in the conducting of a real live course in botany or zoology, and, furthermore, I am inclined to believe that there are few, if any, of the other high school subjects, whose presentation demands as much of the teacher as do these two sciences. It not infrequently happens that the same instructor is called upon to conduct courses in both biology and either physics or chemistry. Those who have had their work thus distributed will, I believe, agree that, given equal training in the two branches of science, the nervous energy expended in their teaching efforts has been largely on the biological side of their program.

The difference in the demands made upon the teacher by the two types of science are due in part to the fact that physics and chemistry are older sciences and are, therefore, more highly organized than are the biological subjects. The textbooks used in either physics or chemistry have reached a high degree of standardization, as have also the materials and apparatus used in

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the laboratory. One may choose his textbook of physics, and with practically no effort order from the supply house a complete set of apparatus designed especially for use with the text in question. This apparatus may be left on the storeroom shelves for months without danger of deterioration. With chemistry much the same thing may be done.

The biological sciences have not as yet been reduced to such a comfortable system, and perhaps never will be. It is not impossible that in the future one may order his biological supplies wholesale so to speak, but the very nature of the subject makes it undesirable that one should use biological supplies in the "canned or bottled" form. Biology is the study of life, and it is obvious that we cannot hope to understand or appreciate biological phenomena if we devote all our time to the study of dead organisms. Even though it be possible to purchase living laboratory materials, our knowledge is not broadened to the desired extent by studies made exclusively in the laboratory. Plants and animals cannot be treated in the same manner as chemicals or physical apparatus. Sodium chloride possesses the same chemical properties whether it be one hundred feet below the surface of the earth and mixed with various other salts, or whether it be in a bottle labelled chemically pure. It may be that living organisms are nothing but physico-chemical-colloidal complexes, but life does not consist of salts and physical conditions. Life is a mobile, dynamic force, which, according to our present knowledge of the structure of protoplasm, carries on its activities within a physico-chemical matrix. Life is a type of energy that has so far never been isolated or measured as we measure the energy of heat, light, mechanics, electricity, etc., The biologist has called this energy of life, biotic energy, and is devoting his time to its understanding.

One of the chief characteristics of life is its sensitiveness to change, whether external or internal. It is a familiar fact that protoplasm consists largely of water, the percentage varying from about eighty-five to ninety-five per cent. The organism then in reality is a solution which, so long as life is present, is in a state of equilibrium with its environment. While, as solutions go, the living organism is fairly stable, we know that on the whole it does not require a great change in the surrounding conditions to so disturb the equilibrium that death will result. For aquatic animals and plants, slight alterations in the chemical reaction of the water in which they are living will quickly result in their death if they are unable to escape from the detri-

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mental conditions. It cannot be expected that plants and animals that have been collected at some remote point and shipped to a distance will retain much of their normal behavior activities, and in many cases their physiological make-up will be decidedly altered. And this is not all; even though the organisms might be secured in a fairly normal condition, one learns little of their real nature in the laboratory. True, the students may form a clear conception of phylogenetic series as such, but they will derive no real understanding of the forces of evolution from their laboratory work. They may become familiar with the mechanics and anatomy of the organisms, but will have little appreciation of the life which makes use of the structures which they have studied.

In the beginning, I grouped the biology instructor's problems under two heads; those dealing with the organization of the course, and those concerned with the securing of the material. There is a decided tendency upon the part of most teachers to leave the organization of their subject to the writers of textbooks. The value of textbooks requires no emphasis, but it should be the task of every teacher to modify the textbook to meet his own needs. At the present time we have many textbooks in elementary biology, but the fact that others are constantly appearing shows that there is as yet no agreement as to the subject matter that should be incorporated in the ideal biology textbook.

The securing of the proper material at the proper time is, however, usually the most serious problem which confronts the enthusiastic teacher who wishes to conduct a real, successful, live course in biology. Difficulty and delay in securing material may play havoc with the most carefully planned course, and there is no biology teacher who has not experienced such difficulties and delays to a greater or less extent. Furthermore, I am sure there is no teacher of the biological sciences who will not gladly listen to any suggestion which may tend to lessen this handicap.

The suggestions which are contained in the following pages are not put forward as a panacea for the troubles of the biological teacher, but I am convinced that they will bear consideration. Let me say at once that I believe that a training in the science of ecology will remove many of the most serious difficulties relating to the conducting of high school biology courses. In this connection, I wish first to outline the advantages which may be confidently expected to accrue as the result of the introduction of ecological methods into high school biology.

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1. The teacher will become thoroughly acquainted with the region in which he is teaching, and will learn where and when to collect his own materials.
2. Ecological methods make it not only easy but essential that the plants and animals be studied together. A course in general biology will automatically result.
3. Ecological methods of analysis necessitate investigations into the texture, composition, etc., of soils. The practical questions relating to agricultural botany and zoology will thus receive attention.
4. The student of ecology must know the animals and plants with which he is working, and the questions of their taxonomy and morphology must be considered.

Ecology has been defined as that branch of physiology which has to do with the relation of the organism to its environment. Ecology is differentiated from the type of physiology with which we are most familiar by the fact that it deals with the organism as a whole and takes little or no account of the physiology of organs. The ecologist is interested in the reactions of the whole organism and is not primarily concerned with the functioning of its liver or the composition of its digestive fluids. In a more general way ecology may be defined as the science of natural history. We do not need to go far back in the history of biology to reach the time, when all biologists were students of natural history. Agassiz, Lubbock, Romanes, Faber, Wallace, Darwin, all were students of nature and did little work in the laboratory. They spent their time studying nature in the field, and we are all familiar with the fact that Darwin and Wallace collected the enormous mass of material upon which they based their individual conceptions of the evolutionary hypothesis, during their excursions into many parts of the world.

With the introduction of the evolutionary idea, backed by so much data, biologists everywhere began a frantic search for more evidence on the subject. It soon became apparent that one of the most fruitful sources of study was to be found in the structure of animals and plants, and as a result, biologists have for the last sixty years devoted a very large proportion of their time to the study of animal and plant anatomy or morphology. A secondary result, of this accumulation of facts concerning the structure of organisms has been, that we have taught in our schools the things which we know best and the high school and college curricula of today reflect this fact in the emphasis laid upon the study of morphology. The botany teacher starts with the blue-green algae and works up through the Protococcales, Volvocales, etc., etc. The student may learn of minute structures to be found in *Pleurococcus* which has been secured from a supply house, and will not hear of the acres of

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this alga that are growing on the trees, fences, stone walls, etc., all about the school building. The zoology teacher will answer every question concerning the complicated nuclear changes during the conjugation of *Paramoecium* without being able to tell the student where the animal is to be found in nature, or what it does under the varying natural conditions. I do not mean to intimate for an instant that I have struck upon the weak points in the experience of all biological teachers, nor do I mean to condemn any teacher for his weaknesses, whatever they may be. They are teaching what they were taught, and the fault lies with the science of biology and not with the teachers.

However, biology is awakening from this lethargy of extreme specialization; we are beginning to realize that the study of structure was nothing but a stage in which we have already lingered too long. We remember that the man who revolutionized the science of biology in 1859 and set the world by its ears, with a nightmare of being a product of evolution rather than of special creation, was not a product of a man-made laboratory, but was a scientist who secured his information at first hand from the laboratory of nature herself. With this in mind, biologists are no longer going afield, as collectors alone, but as students anxious to learn, at first hand, the working methods of nature's own laboratory.

For many years ecologists were troubled and pestered with the statement that natural history was not and could never be a science. According to these critics, nature was such a complex hodgepodge of unknowns that it could never be organized into a science. While this is without doubt more or less true, those who made such statements failed to remember that the evolutionary theory found its origin in this same hodgepodge, and that every science which we know has originated from the same source. The universe in which we live contains more uncovered sciences than man has ever dreamed of. New sciences are arising on every hand. Bacteriology is less than fifty, and protozoology less than twenty-five years old, not to mention the numerous minor "ologies" that are arising on every hand. The founding of a new science requires merely, the accumulation of a sufficient number of related facts, and we have not even gotten below the surface of the tremendous body of facts that is presented to us in nature.

Ecology is the result of an accumulation of facts that show beyond a doubt, a definite relation between the distribution

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and physiology of organisms; in other words, animals and plants select the environments in which they live. The complexity of the relationships involved are bound to be great, which fact but adds to the interest attaching to the science.

All sciences, and especially the laboratory sciences, are readily divisible into descriptive and experimental aspects. In ecology we may make observations and collections which show us that certain animals are characteristic of sandy areas, and others of woods. One species of fish lives in the ripples, and another in the pools of the stream. One insect lives on the ground under the leaves, and another high up in the trees. This analysis may be carried out in great detail and illustrates what is being done in the way of descriptive animal ecology. The descriptive scientist need not necessarily trouble himself with explanations of the facts which he describes, but the experimental worker must determine the why of every fact. Why do certain species of insects live only in sandy regions, and other species in mesophytic woods? Why does one tiger beetle lay its eggs only in clay, and another only in a humus soil? The whys which the experimental ecologist is trying to answer furnish a never-ending list of problems which can be attacked only from the experimental side.

The bearing of all that has gone before upon the teaching of biology in the high school seems to me to be quite clear. Taking it for granted, for there can be no denying the fact, that the place to study nature is in the field, what is there that the high school teacher can do to interest and instruct the student? Let me mention very briefly some of the specific things that may be done. From the descriptive side one of the most interesting phenomena worked out by ecologists is the fact that natural conditions are seldom, if ever, stable. The physiographer finds his science founded upon the fact that the forces of erosion are constantly changing the topography of the earth's surface. The plant ecologist finds that these changes in topography are accompanied by changes in the vegetation of the area, and the animal ecologist finds in turn, that the topographic and vegetational changes are closely followed by changes in the species of animals which inhabit the region. We have then a succession of topographic conditions with an accompanying succession of plant and animal forms. This we call ecological succession. Ecological succession may result from other changes in environment than those related to topography, but the interesting fact at

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this time is that these changes are easily recognized and understood by the high school student. Naturally, we cannot wait for a single area to pass through the different stages, but we can readily find the different stages, represented in different parts of any given region.

There are several other types of succession that are also easily studied. When we think of it, we realize that there must be a change in the types of animals and plants that are active at the different seasons of the year. This seasonal succession study works out exceedingly well if begun in the fall, and can be carried through the winter in a study of hibernation, and taken up again in the spring with the beginning of activity of organisms.

There are also daily successions or rhythms that are easily observed in the field.

Another type of descriptive field work that is always of great interest is the observation of the detailed behavior of a single form for a given time. Thus one may select a certain insect and describe its every movement for ten minutes. This is an exercise that appeals to the students more, and more each time it is done, as their powers of observation become sharpened.

One can make various analyses in the field. The temperatures of the different soils, the difference between air and soil temperature, the differences in temperature in different parts and depths of ponds, etc., are readily obtained by the students. Other simple analyses of environmental conditions, such as the measuring of the light intensity inside and outside a dense wood, and the determining of the rate of evaporation, are operations that require neither complicated nor expensive apparatus, and when these analyses are correlated with the actual distribution of the plants and animals as determined at the same time, they furnish a type of work that has been found to appeal to the high school students in places where it has been tried. For the laboratory there are many experiments which may be performed with inexpensive apparatus, but I cannot go into detail as to these at this time.

I do not wish to leave the impression that I am advocating the crowding out of biology as it is now taught in the high schools, in favor of a course in ecology. The point I wish to make and to emphasize strongly, is that the introduction of ecological methods into the teaching of high school biology, will make the instructor more independent of the textbook and of the supply

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house than he is at present, and at the same time will make it possible for him to put new life into the subject as he comes into closer contact with nature, the giver of all life.

On the other hand, I am not unaware of the difficulties which the above suggestions will entail. Field trips do not always fit well into the regular high school schedule, yet they are absolutely essential to the study of ecology. Classes in high school biology are frequently large and would probably become larger with the introduction of field trips, while a large class in the field soon becomes unmanageable. These and other objections occur at once. However, I believe that most of the objections can be removed by a proper adjustment of schedules and limiting of the numbers allowed to take the course. Of one thing I am certain; with every school situated within working distance of the great laboratory, which nature has already prepared for us, a laboratory that we could never duplicate indoors, however liberal the appropriation, it is not proper that we should continue to limit our biological instruction to the preserved specimen and the dissecting pan. There are many instructors who are already well on the way toward the transfer of the study of biology from the laboratory to the field, and I believe that within the near future this will be the procedure followed by all enthusiastic teachers. With this return to the study of the real, living environment which surrounds us, we must soon develop a type of observer who will see in nature, not a hodgepodge, but a living, dynamic complex of factors that but awaits analysis, and we can rest assured, I believe, that only from such observers will there arise a new Aristotle or a new Darwin to clear away our ever-increasing impedimenta of miscellaneous biological facts, and set us once more on the straight road to a true understanding of life.

LIBERTY LOAN ACTIVITIES.

A conference was held in Washington during the week beginning December 10, which lasted several days, between Secretary McAdoo and other Treasury officials and representatives from Liberty Loan organizations all over the country, which included officials of the Federal Reserve Banks.

Plans for future Liberty Loan campaigns were perfected and an organization at once wider and closer was arranged for. Rural communities and small towns and small cities particularly will feel the effect of the new campaign plans.

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THE APPLICATION OF GENETICS TO BREEDING PROBLEMS.

By Leon J. Cole,

University of Wisconsin, Madison.

Great advances in science have usually followed the development of some new *method* of research. This is strikingly true of genetics. Before the present century the subject of heredity presented a field characterized by indefiniteness—roads were absent or ill-defined, while guideposts pointed this way and that, and seemed to lead to no definite destination. Genetics, perhaps of all sciences, seemed farthest from a possible inclusion among those which are classified as "exact." To be "exact," a subject must have definite units which can be recognized and defined, which exhibit a high degree of constancy, and which consequently can be dealt with statistically—that is, mathematically.

To be sure, unknown to the scientific world at large, the foundations for just such an "exact" treatment of the phenomena of heredity had been laid by Mendel many years before—but Mendel was before his time. It is still less than two decades since his work came to be appreciated, but in that time "Mendel's Law" has been firmly established in the history of science as a real law of nature, expressing a great generality of far broader application than was first dreamed. We no longer hear the question asked, "Do you believe in Mendelism?" any more than, "Do you believe in evolution?" The questions today are as to the details of its application.

Mendel's first and perhaps greatest service was to supply the science of genetics with a *unit* with which to work, albeit a somewhat imperfect and superficial one, and one which has now been largely discarded in favor of another less tangible, in that it cannot be observed directly, but more stable. Mendel's experiments demonstrated the advantage of focussing attention upon single observable qualities, and supplied us with the concept of the *unit character*. He demonstrated seven pairs of alternative unit characters in the garden pea, and showed that they are all inherited in the same fashion. Since 1900 extensive investigations have disclosed in both animals and plants hundreds of characters which follow the same law.

It soon became apparent, however, that there were perhaps even more characters which appeared to be units, but which were not inherited as such. While they were truly unit *characters*, they were nevertheless complex in their inheritance.

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This led to the realization that strictly speaking the characters are not inherited at all; what is really inherited is a *determiner* for the character—something which determines that such a character will develop. The character is only the expression in the development of the individual of the presence of the determiner which causes it. If in its heritage from its parents an individual receives a determiner for a character, the character may develop; without the determiner it cannot. The *determiner*, also commonly called *gene* or *factor*, is then a hypothetical something responsible for a character, but a thing which cannot be studied directly. The factors are units which can be studied only through their manifestation in the characters. Such a study reveals that many characters are complex because they

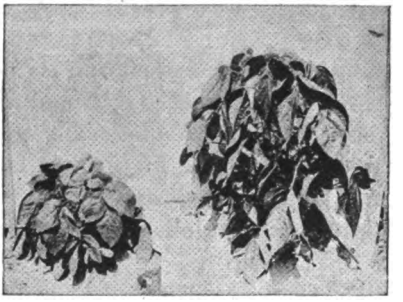

Fig. 1. Difference in growth habit in soy beans. These pictures were taken on the same day. The type represented by the small plant on the left averages about 8 inches shorter and matures nearly a month earlier than that on the right. The difference is due to a single hereditary unit.

depend not upon a single factor, but upon the joint action of several factors. Some of the things which can be studied about factors are: (1) their effect (the characters they produce); (2) their inheritance; (3) their relation to one another (supplementary, complementary, linkage); (4) their location (relation to visible structures in the cell); (5) their constancy; (6) their origin.

Scientific breeding must consist of (1) an *analysis of the hereditary factors* or genes involved, and (2) *manipulation* of these in breeding to produce the combinations which will give the desired results *as expressed in characters*; for the ultimate concern of the practical breeder is, it must be remembered, characters and not genes. Considerable advance has been made in this direction, but in the main scientific breeding is still in the experimental stage. In what follows certain breed-

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ing problems will be discussed from the standpoint of their possible explanation on the factor basis. The illustrations are from the investigations of the Department of Experimental Breeding of the University of Wisconsin.

Selection on the Basis of Factors.

Selection is the process by which all progress must be made in breeding. In practice selection is made on the basis of characters, and notable success has been attained in this way as is attested by the great variety and excellence of plant and animal forms adapted to man's uses. Selection by this method is,

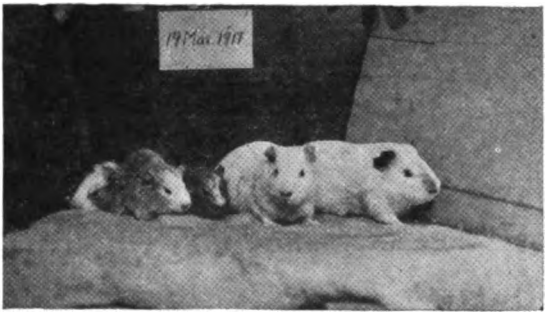

Fig. 2. Albino female guinea-pig (at the right), pink-eyed white male (next to it), and their three offspring, which are pigmented and have dark eyes.

however, a long process and is indirect and uncertain. When selection can be made on the basis of factors it may be direct and certain. The simple condition of this is illustrated by the attempt to produce a true-breeding strain with respect to any dominant Mendelian character, such, for instance, as the difference in growth habit in soy beans shown in Figure 1. One of these is much taller than the other, more spreading in habit, and decidedly later in maturing. This is a simple Mendelian dominant to the shorter, early maturing type—that is, a single factor is responsible for the difference. In this case a single *unit factor* corresponds to a definite *unit character*. Nevertheless, by ordinary selection methods alone, the process of obtaining a true-breeding strain of the tall type might prove to be a long one; a knowledge of the factor relation, however, permits of its easy accomplishment in a single season.

Perhaps a better example of the way in which a knowledge of the heritable factors may lead to a desired result is that of what we have termed our synthetic pink-eyed white guinea pigs. The albino guinea pig, white with pink eyes, is a well-known fancy variety, but it practically always has smutty

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extremities, that is, more or less dark pigment on nose, ears, and feet. It occurred to Dr. Ibsen that a guinea pig meeting all the requirements of a pure white animal with pink eyes might be made up in an entirely different way, by combining the factors for "pink-eyed," "non-yellow," and 'non-extension of dark pigment." This he proceeded to do, and in two or three generations had what he sought—a guinea pig that was not an albino, but is a better albino in appearance than a true albino! Furthermore, this new variety breeds true to type when bred to its kind, but that it is not an albino is indicated by the fact

PER CENT FERTILE EGGS HATCHED

	1913	1914	1915	1916	1917
Inbred pullets	67	49	41	18	0
Checks	67	81	56	64	47

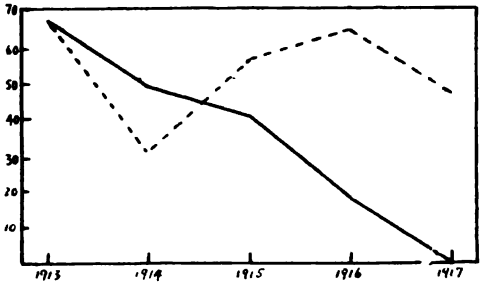

Fig. 3. Table and chart showing the effect on hatchability of eggs of five years of inbreeding of Rhode Island Red fowls. Solid line, inbred pullets; broken line, checks.

that it produces dark-eyed pigmented offspring when bred to an albino (Figure 2).

INBREEDING.

The experiences of different breeders resulting from the practice of inbreeding, or the mating together of closely related individuals, have been very diverse and contradictory, and have seemed to defy explanation. There was a general consensus of opinion that inbreeding tended to "intensify" characters, but it seemed to work impartially on good characters and bad, and there was no telling which would be affected. Furthermore, it was thought that inbreeding lowered vitality, though some failed to get this result. Doubtless many variables are concerned, and in order to eliminate one of these an experiment was planned with Rhode Island Red fowls in which selection was based strictly on a character which supposedly has no vital value, namely, color. One of the most striking results is shown in the table and chart in Figure 3. Hatchability of the eggs

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seemed to be principally affected, so much so in fact that in a period of five years of matings of brother to sister, the hatching power of the eggs steadily declined from sixty-seven per cent to zero, which naturally brought a definite termination to this phase of the experiment.

This result is purely empirical. What is the explanation? Is it not possible that if a different system of selection had been adopted the result would have been different? This seems probable, and is now being tested. In the meantime a

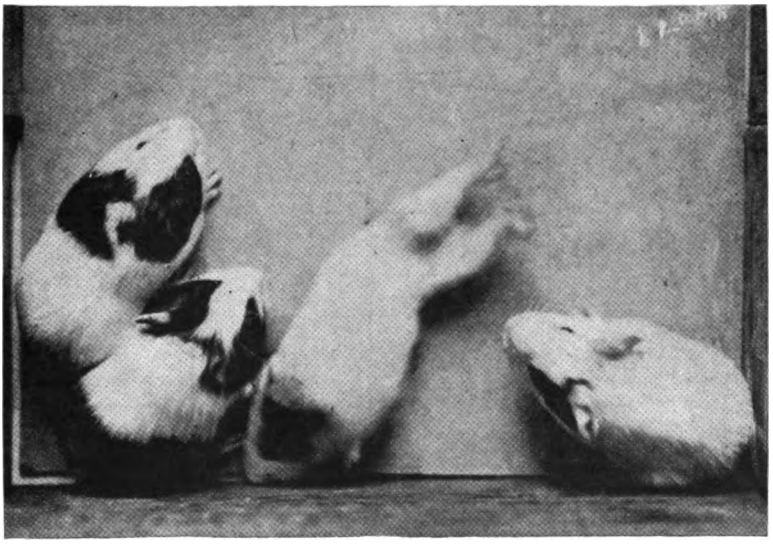

Fig. 4. Litter of four guinea-pigs from parents both of which carried a defective trait in their germ plasm. Three of the offspring are normal, while one is defective. The trembling of the legs is indicated by the blurring of the image.

plausible explanation is at hand on a factor basis. It is first necessary to recall that all the heritable factors an individual can receive must come directly from one or other of its parents, and indirectly from ancestors more remote. As the number of the possible ancestors is limited, the possible diversity of factors is likewise limited. With close inbreeding, such as mating of brother to sister, it is therefore impossible for any new factors to be introduced into the germ plasm, while on account of Mendelian segregation it is more than probable that factors will be lost out, especially any whose presence cannot be readily inferred from obvious characters. Some of these may be of vital importance and their loss will result in a defective or weakened progeny.

Experiments with fruit flies have shown that there are certain

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factors—units which behave in simple Mendelian fashion—whose presence is absolutely essential to the life of an individual. Their absence produces a lethal effect—in other words, kills the fly. There are doubtless other physiological factors of this sort with varying degrees of importance. Thus we have found a case in guinea pigs where the absence of a particular factor is

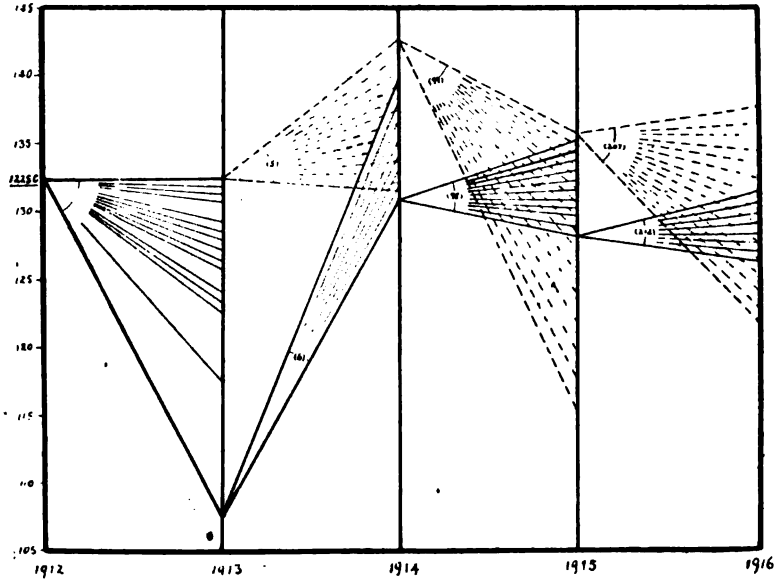

Fig. 5. Pure-line selection in soy beans. Four years of selection with respect to iodine number of the oil were ineffective in producing high and low strains. Broken lines, progenies from the high selective line; solid lines, progenies from the low selective line.

always lethal, but apparently only because such animals always starve to death after they are born. When born, they are as large and strong as any of their litter mates, except for a sort of palsy which prevents their getting about and feeding. Figure 4 shows a litter of four guinea pigs, three of which are normal, while one shows this defect. This case has a strong resemblance to the inheritance of feeble-mindedness and some forms of epilepsy in man.

Pure-Line Breeding.

In certain plants which are naturally self-pollinating, inbreeding is the rule, and good types once established suffer no further deterioration. This makes it very easy for the breeder to isolate and fix desirable types by methods now regularly in use, particularly in the improvement of the cereal grains. On the other hand, since nothing new can be brought in, improvement of a

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pure line by selection alone, that is, without out-crossing, is precluded. This is illustrated in a study of the effects of selection with respect to the chemical character of the oil of a pure-line strain of soy beans (Figure 5). Selections respectively from the highest and from the lowest plants with respect to the degree of saturation of the oil, carried on for a period of four years, have produced no hereditary effect—the progeny of both lines of selection continue to vary over the same range.

The Search for Factors.

By far the greater number of characters of economic importance are of the complex sort, dependent upon several to many

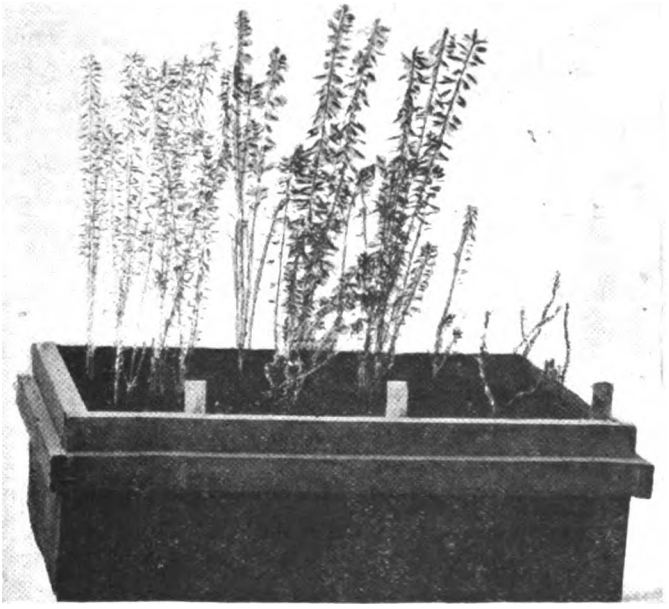

FIGURE 6.

factors. The big task is to analyze such characters—to identify the factors and learn how they are inherited. Such indefinite characters as milk and meat production offer especial difficulties but a beginning is being made even with these. Jersey cattle, representing the most refined dairy type, and Polled Aberdeen Angus, a specialized beef type, were crossed, not with the idea of producing a new breed, nor in fact with any immediate practical object in view, but in order to learn what characters are independent and what go together; what ones, if any, be-

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have in simple Mendelian fashion and what ones are complex—in short, to make just such an analysis as has been suggested.

One other example may serve to show the nature of these investigations. Last year Professor L. R. Jones read before this society a paper in which he described his successful attempts to breed a strain of cabbage resistant to the disease known as "yellows."[1] His experiments demonstrated clearly that there is a distinct heritable difference between the resistant and the non-resistant strains. We are now engaged in studying the method of inheritance of this difference. While the experiments have not yet gone far, they seem to show clearly that *resistance* in this case is not a simple character, but depends upon several, perhaps many, heritable genes. A knowledge of these factors would greatly facilitate the production of a resistant strain that would "breed true." Flax wilt is caused by an organism similar to that which causes cabbage yellows, and flax offers much better opportunities for investigation. If susceptible and resistant strains of flax are crossed, the first generation offspring are usually even more vigorous and fully as resistant as their resistant parents. (Figure 6). In the second generation, however, there is a great variability, and here again the indications are that at least several factors must be present to make a flax plant able to withstand successfully the attacks of the parasitic fungus which causes the wilt.

[1] Jones, L. R. "Some Recent Advances in Plant Pathology," SCHOOL SCIENCE AND MATHEMATICS, Vol. 17, No. 2, February, 1917, pp. 95–100.

WHY YOU MUST BUY LIBERTY BONDS.

War is a glutton that lives on lives and riches. There is no limit to the devouring greed of war. As long as there is an unconquered life, or an undevoured dollar, war is hungry.

When war attacks a nation there is no choice—every able-bodied man knows that he must fight—now or later. Selective drafts may miss a man here and there for a few months, but if the war goes on, a time comes when every man who can walk and carry a gun must go to the colors and fight for the very life of his country, his family, himself.

Remember these things. The nation has a right to take absolutely every dollar of property in the United States for the life and death war against tyranny, autocracy, slavery, and foreign aggression and vassalage. But the nation does not intend to exercise that final and desperate right. No! The Government says: "The nation is fighting for its life. Lend us your money. We will give you Liberty Bonds, secured by all the wealth and sovereign taxing power, bearing 4 1-4 per cent interest, and protected by a good sinking fund, with tax exemptions to make the loan better. Avoid the extreme necessity. INVEST IN ALL THE LIBERTY BONDS YOU CAN."

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IS HIGH SCHOOL SCIENCE ON THE DECLINE?

Editor, SCHOOL SCIENCE AND MATHEMATICS:

In the March number of your journal, page 249, I made the ollowing statement: "A study of the reports of the Commissioner of Education for the past twenty years, incomplete though those reports are, leads to the conclu ion hat the total percentage enrollment in high sch ol science subjects did decline from about 1890 to 910, bu from 1910 to 1915 there was a slight increase." This statement has been challenged by a scientist who e word carries much weight. I should like a little space in which to present the facts upon which I base my conclusion.

On page 487, Volume II, *Repor of the Commissioner of Education for 1916*, under the heading, "Student in Certain Studies in Public High Schools Since 1890," we find the following dat :

PER CENT OF TOTAL ENROLLMENT.

	1890	1895	1900	1905	1910	1915
Astronomy		4.79	2.78	1.22	.53	.28
Physics	22.21	22.77	19.04	15.66	14.61	14.23
Chemistry	10.10	9.15	7.72	6.76	6.89	7.38
Physical geography		23.89	23.37	21.52	19.34	14.58
Zoology					8.02	3.21
Botany					16.83	9.14
General biology						6.90
Geology		5.00	3.61	2.34	1.16	.48
Physiology		29.95	27.42	21.96	15.32	9.48
Dom stic economy					3.78	12.89
Agricu'tu e					4.66	7.17
Totals	32.31	95.55	83.94	69.46	91.14	85.74

In considering these data we should keep the following points in mind:

1. stronomy and geology were more generally tudied in 1890 than at any later date.

2. Physical g ography, botany, oology, and physiology were also well recognized high school subjects in 1890.

3. That many scienti ts hesitate to include all of the teaching of agriculture and domestic economy as science instruction.

4. That general science has never been listed by the Commissioner in his reports.

5. Finally, we should also remember that the fourteen-weeks courses of 1890 and 1895 have generally given place to eighteen-weeks courses or one-year courses in 1915. Until we have some more reliable source of information, I think we shall do well to draw our conclusions from these figures from the Commissioner's reports regarding percentage enrollment in high school subjects.

FRED D. BARBER.

CONCRETE HAS MANY USES.

Concrete, because of its great resistance to fire and to the shock of explosions, is adaptable to a wide variety of uses, according to the United States Geological Survey Department of the Interior. It is cheap, easily and quickly handled, sanitary, and durable, and its characteristics render it of great military importance. Among the military uses to which concrete is put are the construction of armories, barracks, roads, bridges, coast and interior fortifications, gun emplacements, trench linings, bomb-proof shelters, magazines for explosives, tunnels, retaining walls, sea walls, wharves, dry docks, water reservoirs, aqueducts, sewers, sewage-treatment works, incinerators, stables, floors, roofs, munition-factory buildings, warehouses, fuel-oil tanks, barges, and even in the interior of battleships.

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HOW MISSISSIPPI GOT HER HILLS.

Is Mississippi a plain or a plateau, swampy, undulating, hilly, rugged, or what? How many people know? Precise determinations of altitude made by the Government show that its average height above sea level is several hundred feet, or relatively high for a state bordering the Atlantic or Gulf coast, and its valleys are surprisingly deep.

But the most striking features of the surface of the state are the gullies —little valleys carved in bright-colored sands and clays with sides so steep and upper ends so abrupt that they prevent you from going across country anywhere you like even afoot, and although actually only fifty to two hundred or three hundred feet deep, they seem to be good-sized canyons. If you enter one of the canyons at the lower end or find a place where you can climb down a gully wall, you are hidden from the world and may soon get delightfully lost. You may wander about between walls striped horizontally with red, brown, and cream, a new choice of routes continually presenting itself in the intricate ramifications—the whole like a labyrinth; but just as a tributary stream joins its main only at the lower end, there is, as a rule, only one place where any single gully or passage is connected with another.

Even in the southern end of the state, hills reaching over five hundred feet above sea level, or two hundred or three hundred feet above their bases, and some of the uplands are slashed in every direction by innumerable gullies, laying bare the substrata of varicolored irregular layers of sand, clay, and in places gravel.

Nevertheless there is an immense area of arable and fertile land in Mississippi. The soil is so light that with the considerable slope of the hillsides care must be taken to prevent washing and the growth of gullies, which, though disastrous to farming where neglect allows them a start, make charming scenery and afford the geologist a fine opportunity to decipher the complex and in many ways peculiar history of the state.

A short scientific paper dealing with the character of materials exposed in the gullies and a part of the geologic history of the state has recently been published by the U. S. Geological Survey, Department of the Interior.—[*U. S. Geological Survey Press Bulletin.*

HEAVING OF PAVEMENTS BY FROST.

It has long been known by highway engineers that pavements laid on clay soils are more apt to be heaved by frost than those laid on sand or gravel. This has hitherto been attributed to the fact that less water exists in sand or gravel than in clay directly beneath a pavement. Prof. Stephen Taber, professor of geology of the University of South Carolina, has conducted experiments that undoubtedly upset this old theory.

In a paper on "Pressure Phenomena Accompanying the Growth of Crystals," presented before the National Academy of Science last year, Prof. Taber gives an account of what happens when moist clay beneath a stone freezes. The stone cools more rapidly than the clay, so that ice crystals first form at the points of contact between the stone and the clay. The water in the interstices of the clay itself does not freeze so rapidly as water on the surface of the clay, for the freezing point of water in capillary spaces is considerably below that of water in the open. But the freezing of the thin skin of water on the surface of the clay results in more water being fed up from below, very much as a lamp wick feeds up more oil as fast as the oil at the top burns. Then another thin layer of ice forms on the surface of the clay beneath the first layer of ice, and so on, steadily raising the stone by the building up of a layer of ice between the clay and the stone.

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In sand or gravel the same phenomenon does not take place, even when saturated with water. Once the water in the pores of the sand begins to freeze, it freezes progressively downward, because the pores are not so small as to form capillary spaces, and do not, therefore, lower the freezing point of the water.

Experiments were made by Prof. Taber by which the existence of a layer of ice between moist clay and a weight was proved, coincidently with the absence of an ice layer between wet sand and a weight. Hence his theory is established beyond doubt. It also accounts completely for such phenomena as the lifting of blocks of concrete weighing many tons a distance of several inches even when the frost had penetrated the clay soil to a depth of only a few inches.

Highway engineers will not be slow to see the uses to which this new bit of scientific knowledge can be put.—[*Engineering and Construction.*

STENOGRAPHERS AND TYPEWRITERS WANTED—MEN AND WOMEN.

The United States Government is in urgent need of thousands of typewriter operators and stenographers and typewriters. All who pass examinations for the departments and offices at Washington, D. C., are assured of certification for appointment. It is the manifest duty of citizens with this special knowledge to use it at this time where it will be of most value to the Government. Women especially are urged to undertake this office work. Those who have not the required training are encouraged to undergo instruction at once.

Examinations for the Departmental Service, for both men and women, are held every Tuesday, in 450 of the principal cities of the United States, and applications may be filed with the Commission at Washington, D. C., at any time.

The entrance salary ranges from $1,000 to $1,200 a year. Advancement of capable employees to higher salaries is reasonably rapid.

Applicants must have reached their eighteenth birthday on the date of the examination.

For full information in regard to the scope and character of the examination and for application blanks address the U. S. Civil Service Commission, Washington, D. C., or the Secretary of the U. S. Civil Service Board of Examiners at Boston, Mass.; New York, N. Y.; Philadelphia, Pa.; Atlanta, Ga.; Cincinnati, Ohio; Chicago, Ill.; St. Paul, Minn.; St. Louis, Mo.; New Orleans, La.; Seattle, Wash.; San Francisco, Cal; Honolulu, Hawaii; or San Juan, Porto Rico.

TO THE CITIZENS OF AMERICA.

One million, eight hundred thousand of America's brave sons are now serving in the Army and Navy of the United States. Thousand of them are already upon the battle fields of France, fighting and dying to save the liberties and rights of those who stay at home and to secure democracy and freedom against Prussian brutality and military despotism. Their blood already consecrates the soil of noble France.

Who can think of their heroic sacrifices without emotion?

Who can contemplate their trials and sufferings, their dangers and struggles, without setting ablaze the fires of patriotism in his soul?

Who can look upon the blue jacket of the sailor or the khaki jacket of the soldier without admiration for the indomitable hearts that beat beneath—hearts that may soon be stilled in death as the price they pay to save civilization?

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We must support our gallant sailors and soldiers. We must make them swift victors in their fight with the Kaiser. We can do it if we at home do our duty with the same quality of patriotism that animates our men in the trenches. The least duty we can perform—and we should be eager and happy to perform it—is to lend our money, every available dollar we have or can save, to our Government in order that our gallant sons may be supplied with all they need to save America.

No true patriot will fail to buy United States Liberty Bonds of the Third Liberty Loan.

TWO KINDS OF PATRIOTISM.

Mr. Farmer, you have brought a lot of idle land into tillage this spring. You are going to raise all the grain, and forage, and live stock your farm can be made to produce. That's one kind of patriotism and a very necessary kind.

Every farmer who brings an acre of land into cultivation is a soldier on the firing line for liberty and democracy.

But there is another kind of patriotism that is just as necessary. It is just as necessary that the stuff you produce shall be put at the disposal of the fighting forces, as it is that you should raise it.

That means money. You have to have money to pay for the labor of farming your land and producing grain and stock. The Government must have money to buy your produce for the fighting men in France. Money is absolutely necessary to buy food, munitions, clothing, ships, and medical stores.

You are doing your duty in raising the crops, that is very true. But in a war like this one, no man does his full duty who does not do all that he possibly can.

Bring out the grain you have stored away. Sell it at a fair price fixed by the Government.

Bring out the money you have stored up in the banks, or hidden away in your iron box behind the barn. Every dollar is urgently needed.

Invest every idle dollar in Liberty Bonds. The Government will repay you in a few years. Meantime you will receive interest at the rate of 4 1-4 per cent, with valuable tax exemptions to make the investment better. INVEST EVERY DOLLAR YOU CAN IN LIBERTY BONDS.

Every dollar you bring out of concealment means ten dollars added to the fighting capacity of the United States in the world war.

UNIVERSITY OF MICHIGAN SUMMER SCHOOL IN BIOLOGY.

Teachers of the biological sciences in secondary schools and colleges will be glad to know that the University of Michigan offers excellent training by means of field and laboratory work in the ecological, taxonomic, and natural history aspects of zoology and botany during the summer at its Biological Station, located on Douglas Lake, near Pellston, in the northern part of the southern peninsula of Michigan. The station is in the famous summer resort region, being about equidistant from Petoskey, Mackinaw City, and Cheboygan,. Possessing all the climatic advantages of this region, it is sufficiently isolated to be free from the disturbing features of a summer resort and the summer resort crowd. Teachers can recuperate from a hard year's work and yet gain six to eight hours' credit toward a baccalaureate or an advanced degree.

The courses in zoology deal with the natural history of insects, birds, and other vertebrate animals, and the ecology of invertebrates, while special and research work is offered along lines suggested by these courses. In botany, courses deal with the classification of flowing plants, plant

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ecology, and plant anatomy. Research work is offered along ecological, anatomical, and systematic lines. Opportunity for investigation is offered to a limited number of investigators from other institutions upon payment of a small fee.

A teaching staff of well-trained and experienced men has been chosen from the faculties of the University of Michigan, University of Colorado, Kansas State Agricultural College, and Carthage College. The session begins on July 1 and ends on August 23.

Those desiring further information in regard to courses, credits, and living conditions may address George R. La Rue, Director of the Biological Station, University of Michigan, Ann Arbor, Mich.

CLASS ROOM SAYINGS.

"Water cannot be cooled above the boiling point because the boiling point of water and the condensing temperature of steam are the same, so the water would condense in steam."

"Take a *magnate* and find out with a compass which end is north and which is south. Then rub the south end of the magnate on the end of the bar marked plus."

SEATTLE, THE FOURTH PORT OF THE UNITED STATES.

During 1917, Seattle passed San Francisco in the value of her foreign trade, which amounted to $600,000,000, thereby taking rank as the fourth port of the United States. This marked advance is due, of course, to the present abnormal conditions. War has revolutionized shipping routes. Supplies for the Russian armies constituted a large part of Seattle's exports. But her admirable geographical situation fits Seattle to maintain the position she has reached. Located at the most advantageous point in an extensive network of waterways, with sufficient depth of harbor and convenient dockage, within easy reach of a productive district, a position of local prominence was early assured her. Lumber and fish constituted the first important trade. Forest products were in demand along the entire west coast of North and South America. The cities on the treeless Peruvian and Chilean coasts and even far interior towns of the Andes called for the pine of Washington's forests. Railroads, when they came, made the entire Northwest a hinterland for Seattle, while no point was so well situated as a gateway to the gold and fur-bearing regions of Alaska. When commerce with the Far East was opened up, Seattle was ready to offer the shortest route by which wheat and manufactured articles from the northern United States could be exchanged for the products of the Orient (see W. M. Gregory: "The Growth of the Cities of Washington," *Journ. of Geogr.*, May, 1916). The heavy war shipments to Asiatic Russia have now made her America's foremost Pacific port.—[*Geographical Review.*

PATRIOTIC TEACHERS.

There is no more loyal and patriotic class of people in the United States than its Science and Mathematics Teachers. They are showing their loyalty not only in the purchase of Third Liberty Loan Bonds themselves, but in showing to their pupils how necessary it is that they should invest their savings in this most important enterprise, at the same time urging their parents to purchase their Bonds until the pinch is actually felt. Teachers, push this sale to the utmost!

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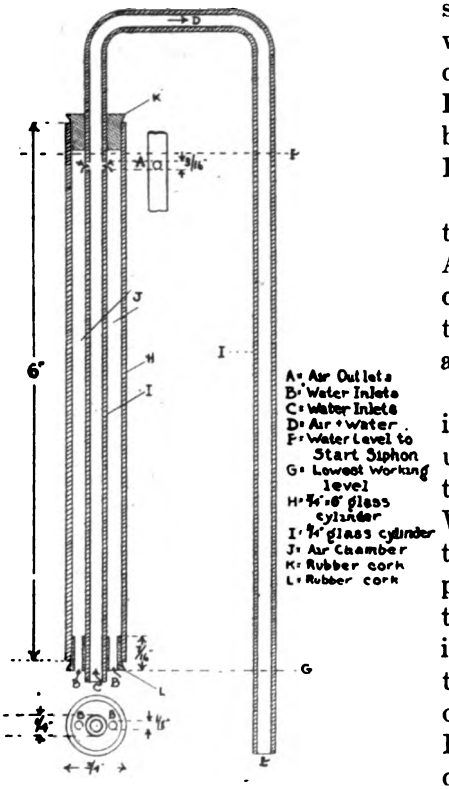
LABORATORY METHOD OF MAKING A SELF-STARTING SIPHON.

By Waller Bonner,

High School, Montclair, N. J.

This siphon is constructed as shown in the drawing. It consists of a long bent tube I, which runs through the center of a glass cylinder H, to which it is attached by rubber stoppers K and L.



Two holes are made in the tube I and are lettered A-A in the drawing. Two other holes made through the lower rubber stopper are marked B-B.

In operation the siphon is thrust into the liquid until the water rises in tube I to the level F. Water also passes in through openings BB, compressing the air and forcing the air out through A-A into I. This air pushes the water above A-A over the bend in the tube I. When the air in the cylinder has been forced out through the opening in I the entire siphon fills with water and operates as a simple bent tube siphon.

By following this method of construction, a siphon can be made from stock materials carried in every laboratory.

MINERAL RESOURCES OF THE KANTISHNA REGION.

A preliminary report on the mineral resources of the Kantishna region, Alaska, has just been published by the United States Geological Survey as Bulletin 662-E. This paper gives a rather complete account of the mining activities of this interesting area during the last twelve years and descriptions of the many small producing placer mines and of the promising, but as yet unproductive gold, silver, and antimony prospects. It may be obtained free on application to the Director of the United States Geological Survey, Department of the Interior.

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PROBLEM DEPARTMENT,

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

SOLUTION OF PROBLEMS.

530. *Proposed by N. P. Pandya, Sojitra, India.*

(*This is repeated—no solutions received.—Ed.*)

If $\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta$, find $\sin 2\theta+\cos 2\theta$.

Solution by Nelson L. Roray, Metuchen, N. J.

$$\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta.$$

$$\tan^2\theta+\tan^2\theta = \cos^2\theta+\cot^2\theta-\sin^4\theta$$

$$\tan^2\theta(\sin\theta+\cos^2\theta) = \frac{1-\sin^4\theta-\sin^6\theta}{\sin^2\theta}$$

$$\sin\theta\cos\theta+\cos^2\theta = \frac{\cos\theta}{\sin\theta}\left(\frac{1-\sin^4\theta-\sin^6\theta}{\tan^2\theta}\right)$$

$$\cos 2\theta+\sin 2\theta = \frac{2-2\sin^4\theta-2\sin^6\theta-\tan^4\theta}{\tan^4\theta}$$

$$= 2\cot^4\theta-2\cos^4\theta-2\sin^2\theta\cos^4\theta-1$$

$$= 2\cot^4\theta-4\cos^4\theta+2\cos^6\theta-1.$$

Algebra.

551. *Proposed by Murray J. Leventhal, New York City.*

Show that the sum of the squares of the reciprocals of the natural numbers is $1/6\pi^2$.

Remark by Nelson L. Roray, Metuchen, N. J.

This is a standard series and is proved by considering the following two expansions:

$$\tan x = x+x^3/3+2x^5/15+17x^7/315+ \cdots\cdots$$

$$\tan x = \frac{2(2^2-1)x}{\pi^2}S_2+\frac{1}{2}\cdot\frac{4(2^4-1)x^3}{\pi^4}S_4+\frac{1}{3}\cdot\frac{6(2^6-1)x^5}{\pi^6}S_6+ \cdots\cdots$$

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where

$S_2 = \Sigma 1/n^2 \quad S_4 = \Sigma 1/n^4$

Equating coefficients we have,

$6/\pi^2(1/1^2+1/2^2+1/3^2+ \cdots\cdots) = 1$

or

$\pi^2/6 = 1/1^2+1/2^2+1/3^2+1/4^2+ \cdots\cdots$

Also

$$\frac{1}{2} \cdot \frac{4(2^4-1)}{\pi^4} S_4 = \frac{1}{3},$$

$\therefore S_4 = \pi^4/90.$

It is evident the above expansions enable one to find the value of S_{2m}.

In *Hobb's Trigonometry* is found the solution given above.—N. L. R.

MR. F. J. MCMACKIN *sent a solution by means of calculus. We regret lack of space to publish. One incorrect solution also received.—Ed.*

Geometry.

552. *Proposed by Norman Anning, France.*

Given a regular n-gon, to construct a regular $2n$-gon having the same center and the same length of side.

I. *Solution by W. W. Gorsline, Crane Technical High School and Junior College, Chicago.*

A central angle of an n-gon $= 360/n$ and that of a $2n$-gon $= 360/2n$. Let AB be a side of a regular n-gon in a circle of center O and AC, one-half of one side. $\angle$COA will subtend a side of the regular $2n$-gon. Extend CO to circumference at D. Let EF be a side of the regular $2n$-gon in a concentric circle of center O. $\triangle$'s DOA and EFO are similar and their altitudes or apothems of the $2n$- and n-gons are in proportion to EF and AD. The apothem of the regular $2n$-gon is a 4th proportional to EF, AD, and the apothem of the n-gon and can, therefore, be constructed and then the $2n$-gon.

II. *Solution by the Proposer.*

Let AB be a side of the given regular n-gon, and O its center. On AB, on the side remote from O, construct a rectangle ABCD, having

$$BC = OB.$$

Then DC is a side of the required regular $2n$-gon. This method yields easiest construction of regular dodecagon.

III. *Solution by Nellie F. Henderson, Martins Ferry, O.*

Let AB be one side of a regular polygon of n sides, having its center at O.

Draw AD and BC $\perp$ AB at points A and B, respectively.

Draw OA and OB; then draw OE $\perp$ AB from O.

Bisect the $\angle$s AOE and BOE and extend their bisectors until they cut AD and BC at F and G, respectively.

FG will be a side of a regular polygon of $2n$ sides.

Solutions were also received from A. F. FAIRBANK, GERTRUDE BUCK, T. H. BRIGGS, *and* PHILOMATHE.—*Ed.*

553. *Proposed by W. W. Gorsline, Chicago.*

Of all possible triangles inscribed in a given segment the isosceles triangle has the maximum perimeter.

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I. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let c be the chord of the given segment, and a and b the variable sides of the triangle.

Then

$$a = c\frac{\sin A}{\sin C}, \quad b = c\frac{\sin B}{\sin C}.$$

$$a+b = \frac{c}{\sin C}(\sin A+\sin B)$$

$$= \frac{2c}{\sin c}\sin \tfrac{1}{2}(A+B)\cos \tfrac{1}{2}(A-B)$$

$$= a \text{ maximum when } A = B.$$

II. *Solution by Philomathe, Montreal, Canada.*

Let $\triangle ACB$ be isosceles, and ADB any other triangle. Produce AC and AD in E and F respectively, making CE = CB, and DF = DB; join EB and FB.

Angles E and F are equal, therefore points A, B, F, E are concyclic. But, because AC = CB = CE, angle ABE is right and AE is a diameter. Therefore, AE > AF, or AC + CB > AD + DB; that is, perimeter of $\triangle$ ABC is greater than perimeter of ADB.

Solutions were also received from W. W. Gonsline, Murray J. Leventhal; *an additional one from* Nelson L. Roray, *and one incorrect solution.—Ed.*

554. *Proposed by the Editor.*

Prove by a direct method that if two angle bisectors of a triangle are equal the triangle is isosceles.

[This theorem being a familiar one, a recently published solution by Dr. Artemus Martin in the *American Mathematical Monthly* attracted our attention and it is desired to make a collection of different direct methods. Send also copied methods (with references).—*Ed.*]

I. *Solution by Irvin E. Kline, Atlantic City, N. J., and by W. W. Gorsline, Chicago.*

Let ABC be the triangle in which the bisectors AD and BE are equal.

Through E draw a line EF, intersecting BC so that $\angle BEF = \angle BAD$, and through B draw a line intersecting EF so that $\angle FBE = \angle ADB$. Draw FG $\perp$ AC, and AH $\perp$ FB produced. Since $\angle$s BAD AND ADB are two $\angle$s of a $\triangle$, they are together less than two right $\angle$s and hence EF and BF will meet.

$\because \triangle ABD = \triangle EFB$; $\therefore BD = BF$ and $AB = EF$.

K is the point where bisectors AD and BE intersect.

$\angle AKB = \angle KAE + \angle AEK = \angle BEF + \angle AEK = \angle AEF$.

$\angle AKB = \angle KDB + \angle DBK = \angle FBK + \angle KBA = \angle FBA$.

$\therefore \angle AEF = \angle FBA$; $\therefore \angle FEG = \angle ABH$; $\therefore \triangle FGE = \triangle AHB$.

$\therefore GE = HB$ and $GF = HA$; $\therefore \triangle FGA = \triangle AHF$.

$\therefore GA = HF$ and $AE = BF = BD$; $\therefore \triangle ABE = \triangle BAD$.

$\therefore \angle EAB = \angle DBA$; $\therefore AC = BC$.

Note: The above proof is taken mostly from *Loomis' Original Investigations.* Loomis also gives an indirect method of proof.—I. E. K.

II. *Solution by Nelson L. Roray, Metuchen, N. J., Irvin E. Kline, Atlantic City High School, and Murray J. Leventhal, New York City.*

The formula for the bisector of an angle is

$$t_a = \frac{2}{b+c}\sqrt{bcs(s-a)}.$$

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$$t_b = \frac{2}{a+c}\sqrt{acs(s-b)}.$$

$$\therefore \frac{2}{b+c}\sqrt{bcs(s-a)} = \frac{2}{a+c}\sqrt{acs(s-b)}.$$

$$\therefore a = b$$

and the triangle is isosceles.

III. *Second solution by Nelson L. Roray, Metuchen, N. J.*

Let CAB be the given triangle, and the bisector of $\angle B$ intersect CA at D, of $\angle A$, CB at E.

Then

$$CD = \frac{ab}{a+c}, \quad CE = \frac{ab}{b+c}.$$

and

$$\frac{\overline{AD}^2}{BD^2} = \left(\frac{ab}{a+c}\right)^2 + a^2 - \frac{2a^2b}{a+c}\cos C,$$

$$AE^2 = \left(\frac{ab}{b+c}\right)^2 + b^2 - \frac{2ab^2}{b+c}\cos C.$$

$$\therefore \left(\frac{ab}{a+c}\right)^2 + a^2 - \frac{2a^2b}{a+c}\cos C = \left(\frac{ab}{b+c}\right)^2 + b^2 - \frac{2ab^2}{b+c}\cos C.$$

Whence $a = b$

and the triangle is isosceles.

IV. *Third solution by Nelson L. Roray, Metuchen, N. J.*

Let CAB be the given triangle, and the bisector of $\angle B$ intersect CA at D, of $\angle A$, CB at E.

$$\angle CDB = \angle A + \angle B/2 \qquad \angle CEA = \angle B + \angle A/2.$$

$$\frac{\sin(A+B/2)}{\sin B/2} = \frac{a}{CD}, \quad \frac{\sin(B+A/2)}{\sin A/2} = \frac{b}{CE}$$

$$\therefore \frac{\sin(A+B/2)}{\sin(B+A/2)} \cdot \frac{\sin A/2}{\sin B/2} = \frac{a}{b} \cdot \frac{CE}{CD}.$$

Also,

$$\frac{\sin A/2}{\sin C} = \frac{CE}{BD} \text{ and } \frac{\sin B/2}{\sin C} = \frac{CD}{AE} \qquad \therefore \frac{\sin A/2}{\sin B/2} = \frac{CE}{CD}.$$

Hence,

$$\frac{\sin(A+B/2)}{\sin(B+A/2)} = \frac{a}{b} = \frac{\sin A}{\sin B}$$

and, as is easily proved, $\angle A = \angle B$ and the triangle is isosceles.

V. *Fourth solution by Nelson L. Roray, Metuchen, N. J.*

Let the interior bisectors of angles A and B intersect CB and AC at E and F, respectively, and each other at I, and the exterior bisectors of angles B and C at R and R′, respectively.

Let $AE = BF = m$, $IE = a$. $RE = x$, $IF = c$, and $R'F = y$. Then we have at once,

$$\frac{x}{x+m} = \frac{a}{m-a},$$

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$$\frac{y}{y+m} = \frac{c}{m-c},$$

and

$(y+c)(m-c) = (x+a)(m-a)$ (since $\angle R = \angle R'$).

Eliminating m and y from these equations, we get an equation, one of whose factors is $a-c$, whence it easily follows that the triangle is isosceles.

VI. *Solution by Philomathe, Montreal, Can., and Norman Anning France.*

CD and BE bisect angles C and B respectively.

We have CD = BE = m, to prove that AB = AC or $b = c$.

Let CE = x, and BD = y.

From geometry, we know that

$$x = \frac{ab}{a+c} \text{ and } y = \frac{ac}{a+b}.$$

Also,

$$m^2 = ac - x(b-x) = ab - y(c-y).$$

Hence,

$$ac - \frac{ab}{a+c}\left(b - \frac{ab}{a+c}\right) = ab - \frac{ac}{a+b}\left(c - \frac{ac}{a+b}\right)$$

or,

$$c - \frac{b^2}{a+c}\left(1 - \frac{a}{a+c}\right) = b - \frac{c^2}{a+b}\left(1 - \frac{a}{a+b}\right), \quad \text{since } a \neq 0;$$

or, after a few transformations,

$$(b-c)[(a+b)^2(a+c)^2 + bc(a^2+b^2+c^2+2ab+2ac+bc)] = 0.$$

Now, the factor between brackets is essentially positive, therefore $b-c = 0$, or $b = c$.

Three incorrect solutions were received.—Ed.

Trigonometry.

555. *Proposed by Daniel Kreth, Wellman, Ia.*

Determine a point P within a triangle ABC such that the angles PAB, PBC, PCA, shall be equal.

I. *Solution by Murray J. Leventhal, New York City.*

Let α be this angle. Then APB = $\pi - B$, BPC = $\pi - C$, and CPA = $\pi - A$. By the Law of Sines,

$$AP = \frac{c\sin(B-\alpha)}{\sin B} = \frac{b\sin\alpha}{\sin A} \qquad (1)$$

since

$$\sin(\pi - B) = \sin B, \text{ and } \sin(\pi - A) = \sin A.$$

From (1) we obtain

$$\frac{\sin(B-\alpha)}{\sin\alpha\sin B} = \frac{b}{c\sin A} = \frac{\sin B}{\sin C\sin A} = \frac{\sin(A+C)}{\sin C\sin A}.$$

Expanding the numerators of the first and fourth ratios and dividing through by their respective denominators, we get,

$$\cot\alpha - \cot B = \cot A + \cot C$$

or,

$$\cot\alpha = \cot A + \cot B + \cot C$$

as the required relation.

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II. *Construction by Irvin E. Kline, Atlantic City, N. J.*

Note: Mr. Kline appends proof of the construction but it is omitted for lack of space.—*Ed.*

Construction: Through point B erect a perpendicular to a. Through A draw a line so that it will form with c and this perpendicular an isosceles triangle. With vertex B_1 of this isosceles triangle as center and B_1 A as radius, describe a circle. Through A erect a perpendicular to c, and through C draw a line so that it will form with b and this perpendicular an isosceles triangle. With vertex A_1 of this isosceles triangle as center and A_1 C as radius, describe a circle. Likewise at C draw a perpendicular to b and construct an isosceles triangle. With C_1 as center and C_1B as radius, describe a circle. These three circles will intersect in a point P such that $\angle PAB = \angle PBC = \angle PCA$.

Another point may be found by going around the triangle in the opposite direction. These points are called *Brocard's Points.*

See Weber and Wellstein: *Encyclopadie der Elementar Mathematik,* Vol. II.

Solutions were also received from Philomathe, and Nelson L. Roray, one incorrect solution was received.—Ed.

PROBLEMS FOR SOLUTION.

Algebra.

566. *Proposed by R. T. McGregor, McArthur, Cal.*

Solve the equation

$$\sqrt[4]{x+27}+\sqrt[4]{55-x} = 4.$$

Geometry.

567. *Proposed by N. P. Pandya, Sojitra, India.*

Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

568. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

The line that joins the orthocenter of a triangle to any point on the circumscribed circle bisects the line joining the feet of the perpendiculars dropped from this point upon the three sides of the triangle.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

Trigonometry.

570. *Proposed by R. T. McGregor.*

Find θ when

$$\frac{\tan^3\theta+\sec^3\theta}{\csc\theta-\operatorname{ctn}\theta} = \frac{1}{3}.$$

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SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Science Tests.

To those who have asked to be enrolled as cooperating on science tests some lists in physics have already been mailed. Chemistry will follow. Suggestions are desired. Returns will be compiled as rapidly as received and communicated to all as quickly as possible.

J. P. Drake, Emporia, Kan., and Katherine Weaver, Emma Willard School, Troy, N. Y., have asked to be added to the list of those who wish tests.

Acknowledgment.

The receipt of examination papers is acknowledged with thanks from Charles J. Pieper, University High School, Chicago, Ill.; H. E. Hammond, Kalamazoo, Mich.; Katherine Weaver, Troy, N. Y.

QUESTIONS AND PROBLEMS FOR SOLUTION.

302. *What do you think of the following test in General Science, especially Part II?*

UNIVERSITY HIGH SCHOOL, CHICAGO—SECOND SEMESTER—FEBRUARY 6, 1918.

General Science—Part I.

Answer all questions in order. Each question counts 15 points.

1. Why is a room cooled more rapidly if a window is opened at the top than when opened at the bottom? Would the change of air be more or less rapid if the window were opened at both the top and bottom? Why?
2. Explain, using a drawing if you think it will help you in the explanation, how a simple mercury barometer is made. How does it work?
3. How does yeast cause bread to rise? Explain fully.
4. How are carbohydrates made in the leaf blade, and what are four parts of the blade which take part in its manufacture?
5. Name three important gases of the air. How may one of these be made in the laboratory?
6. Tell about two experiments performed in the laboratory which prove to you that air is matter.

General Science—Part II.

There are forty blank spaces in the paragraphs that follow. To complete each statement write the proper word in the blank space. In several cases one of several words may be used. Each word correctly written counts 1–2 point.

1. Air pressure is measured by means of a ..... There are two kinds: ..... and ..... If either of these instruments is taken up in an aeroplane it will show a ..... pressure than at sea level. If carried into a deep mine it will show a ..... pressure. On a fair day the pressure is ....., while on a rainy day it is .....

2. The instrument which is used to take the temperature of the air is called ..... There are two kinds: ..... and ..... We commonly use the ..... kind on which the average temperature of a living room should be approximately ..... degrees and the normal temperature of the body is ..... degrees.

3. Air ..... when heated and ..... when cooled. Therefore warm air will .... from the warm ground because the cold air has a ..... weight. The air is warmer in summer than in winter because the rays of the sun strike the earth more ..... in summer. Also the days are ..... in winter than in summer.

4. In a cloud from which rain is falling the .... is .... per cent. If the temperature is below 32 degrees F. the

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water vapor will come out of the air in the form of ..... If the temperature is above 32 degrees F. the water vapor will come out in the form of ..... When the air is nearly saturated and the air is then cooled a ..... will appear.

5. Winds blow from an area of ..... to an area of ..... pressure. The velocity of the wind depends upon the ..... of the pressures. A cyclone occurs in a ..... pressure area. If the wind sets in from the south or southeast and the air pressure is decreasing a ..... is approaching from a ..... direction. A south wind from the Gulf has a ..... humidity and often brings rain because it is ..... as it comes north.

6. Of the three forms of matter the molecules are farthest apart in the ..... form. The gases in the air do not separate into layers according to their weights because they ..... An ..... is smaller than a molecule, and a molecule of water is composed of two ..... of ..... and one of .....

7. Plants which do not contain chlorophyll are called ..... plants. Of the three kinds of plants which occur in the air ..... causes milk to sour.

Please answer questions numbered 303 and 304 in the following list.

SHEFFIELD SCIENTIFIC SCHOOL—SEMI-ANNUAL EXAMINATION—JUNIOR CLASS—JANUARY 29, 1918.

Physics—Engineering Science Group.

1. (*a*) Find the torque acting on a bar magnet when placed in any position in a magnetic field.

303. (*b*) Find the magnetic intensity on the prolongation of the axis of a bar magnet 30 cm. from one of the poles, the strength of each pole being 1200 units and the distance between the two poles being 20 cm.

2. (*a*) Derive an expression for the potential at a point due to a charge of electricity at some distance.

(*b*) Find the potential at the center of a square 10 cm. on a side, due to charges of $+50$, $+100$, -150, and $+200$ units placed at the middle points of the sides of the square.

(*c*) Find the electrical energy of a sphere of radius 10 cm. when charged with 200 units of electricity.

3. (*a*) Give a rule for telling the direction of the magnetic field about a current.

(*b*) Obtain a value for the magnitude of the magnetic field inside of a solenoid.

4. (*a*) What are the essential features of a voltmeter; of an ammeter?

(*b*) A galvanometer of 20 ohms resistance gives a deflection of 50 divisions for a current of 1 milliampere. How should the instrument be modified to serve as an ammeter with one division per ampere?

5. Define, isogonic line, electrostatic capacity, electromagnetic unit of quantity, neutral temperature for a thermo-electric couple, a henry.

6. Two cells each having an E. M. F. of 1.6 volts and an internal resistance of .4 ohm are connected in parallel and joined to two resistance coils of .2 and .3 ohm respectively, which are also connected in parallel. What is the current in the .3 ohm coil and what is the drop of potential between its ends? How much heat is generated in this coil per minute?

7. (*a*) Define magnetic induction; magnetic flux; magnetic permeability.

(*b*) What is the character of the relation between the magnetic induction in iron and the magnetizing field?

8. (*a*) Obtain an expression for the electromotive force in a circular coil of wire rotating in a uniform magnetic field.

304. (*b*) What is the maximum E. M. F. in such a coil of 50 turns having a diameter of 40 cm. when this rotates 1200 times per minute about an axis perpendicular to a field of 300 units?

9. (*a*) Give Fleming's rule for the direction of the force acting on a conductor when placed in a magnetic field.

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(*b*) Find the force per unit length in a conductor carrying 20 amperes whose length is parallel to the direction of a magnetic field of .3 unit.

(*c*) What is the nature of the interaction between two parallel conductors carrying currents?

10. (*a*) Explain the theory of ionization by collision, and tell how it accounts for a spark discharge.

(*b*) What are radioactive substances?

(*c*) State the main facts about each of the different kinds of rays given off by radioactive substances.

SOLUTIONS AND ANSWERS.

Apropos of the answers to question No. 284 in the March issue.
By H. E. Hammond, Central High School, Kalamazoo, Mich.

Messrs. Smith and Drake both are in favor of having all the laboratory notes made in the laboratory. The problem is not one to be dismissed in a few words, but depends largely on the time for laboratory work that is available. In many small schools this is the same as a class period, forty-five minutes, and elsewhere it runs up to three hours, 180 minutes. We have seventy-five minutes, and it is difficult to get it more than once a week. Manifestly, all this time must be used to get the first draft of the results, but we use a carbon copy book for rough work, and the duplicate is left at the end of the period. The complete write-up *has* to come later. All possible efforts have been made to allow the pupils to have every minute of the seventy-five for actual work, and the large majority can finish the usual amount of work in that time, though seldom can more than four trials be taken, and often only two. Are many trials necessary or desirable in high school? The writer would like to hear from others who have the same problem to meet.

Second-Year Physics. Comment by W. A. Zinzow, Wausau, Wis.

I have but recently become a very much interested reader of SCHOOL SCIENCE AND MATHEMATICS, and particularly of the "Science Questions Department."

I have been in charge of the Physics Department of the Wausau High School during the past three years. This year I have introduced, with the cooperation of the Board of Education and our Superintendent and Principal, a second year's work in physics in the form of a year's course in electricity. In my regular physics work I am giving the usual amount of time to the study of electricity, but during the second year we are taking up the subject in a more intensive manner.

During the past semester we reviewed some of the fundamental principles of electricity, going into details a little more than usual. After that we spent about six weeks on measurements, such as Ohm's Law problems in their various forms, measurements of resistance and power. We devoted the last six weeks of the semester to a somewhat comparative study of storage batteries. I am enclosing a copy of the examination questions that the class worked on at the end of the semester.

During the present semester we are studying the theory of direct and alternating current generators, laying special stress on *why* certain actions result, rather than their mathematical relations. Up to the present time we have been using Millikan-Crocker-Mills *Practical Lessons in Electricity* and Evans *Manual of Electricity* as textbooks, together with Archbold *A Laboratory Course in Practical Electricity* as a laboratory outline. From now on for about six weeks the class is going to spend its laboratory periods in the various electric shops about town under the supervision of the men in charge of the shops. After that brief period of training is over they will go out individually with the workmen from the various shops as helpers for wiremen, electric instrument testing, telephone work, etc. In this way these boys will be able to fill the places of men who will be drawn in the next draft, in addition to making their course to a certain extent practical rather than purely theoretical.

I have a class of twelve boys, and every one of them has been at work with all kinds of spirit, and I believe they are getting a great deal out of it.

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RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

The Quantum Theory and Molecular Structure.

By Robert C. Colwell, Geneva College, Beaver Falls, Pa.

The inability of the classical mechanics to explain the spectra of the elements is at once apparent if we fix our attention upon the hydrogen spectrum. The atom of this element consists of a single electron rotating about a central nucleus. Under the inverse square law, its energy should be gradually expended in radiation, and the molecule should eventually reach a state in which no radiation will take place. Then, too, it seems impossible for a single rotating electron to give the complicated line spectrum of hydrogen. Bohr, however, has shown how a modification of the quantum theory will account for all the lines of the hydrogen spectrum. In this theory, he supposes that the electron may rotate about the central nucleus in a series of rings, and that the electron jumps at once from one ring to the other without revolving in the intermediate orbits. The development of this theory depends upon two very simple theorems in elementary physics.

First: When a body is moving uniformly in a circle, the centripetal force is given by the equation:

$$F = \frac{mv^2}{r} \qquad (1)$$

in which v is the velocity of the body of mass m, and r the radius of the circle.

Second: The potential energy of an electron e at a distance r from a nucleus E is given by the equation:

$$\text{P. E.} = \frac{Ee}{r} \qquad (2)$$

in which E and e denote the charges of the nucleus and the electron respectively.

Suppose the electron revolves in its orbit n times per second. Then, since r is the radius, the

$$\text{velocity } v = 2\pi nr \qquad (3)$$

Under the Newtonian Law, the force of attraction between the nucleus and the electron is

$$F = \frac{Ee}{r^2} \qquad (4)$$

If there is equilibrium this force is equal to the centripetal force. Thus from (1) and (4)

$$F = \frac{mv^2}{r} = \frac{Ee}{r^2} \qquad (5)$$

The potential energy of the electron becomes, from (2), (3), and (5)

$$\text{P. E.} = \frac{Ee}{r} = 4\pi^2 mn^2 r^2 \qquad (6)$$

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The kinetic energy of the electron is,

$$\text{K. E.} = \tfrac{1}{2}mv^2 \tag{7}$$

$$= \tfrac{1}{2}\frac{Ee}{r} \tag{8}$$

The work required to move the electron from its orbit to a position of *rest* at infinity is

$$\text{P. E.} - \text{K. E.} = \frac{Ee}{r} - \tfrac{1}{2}\frac{Ee}{r} = \tfrac{1}{2}\frac{Ee}{r} \tag{9}$$

Let us call this amount of energy W. Now let us assume that W does not vary continuously but only by definite increments, such that

$$W = \tfrac{1}{2}Thn \tag{10}$$

in which T is a positive interger, h the Planck constant, and n the number of revolutions per second.

When the electron is moving in a circle of radius r_1, corresponding to a value of $T = T_1$, from (6) and (10),

$$W_1 = \tfrac{1}{2}hT_1n = \tfrac{1}{2}hT_1\frac{\sqrt{Ee}}{2\pi\sqrt{mr^3}} \tag{11}$$

Substituting the value of r_1 from (9),

$$W_1 = \frac{2\pi^2mE^2e^2}{T_1^2h^2} \tag{12}$$

If the electron is moving in another circle of radius r_2,

$$W_2 = \frac{2\pi^2mE^2e^2}{T_2^2h^2} \tag{13}$$

Bohr assumes that the difference in energy between (12) and (13) is given out as a monochrometic radiation as the electron jumps from radius a_1 to radius a_2.

Then

$$h\nu = W_1 - W_2 = \frac{2\pi^2mE^2e^2}{h^2}\left(\frac{1}{T_1^2} - \frac{1}{T_2^2}\right) \tag{14}$$

Equation (14) is Bohr's equation for the spectral lines. If, as in hydrogen, $E = e$,

$$\nu = \frac{2\pi^2me^4}{h^3}\left(\frac{1}{T_1^2} - \frac{1}{T_2^2}\right) \tag{15}$$

If $T_1 = 1$ and $T_2 = 1, 2, 3, \ldots\ldots n$ in succession, the frequencies calculated from equation (15) are exactly the frequencies observed in one of the series of lines in the hydrogen spectrum. If $T_1 = 2$, another series is given, and so forth. Three of these series, the Balmer, Lyman, and Paschen series, have been observed.

THRIFT STAMPS.

It is pointed out by the Treasury Department that Thrift Stamps are not made redeemable in cash for the reason that these stamps are simply intended as a convenient method for the small savers to accumulate enough to purchase War Savings Stamps, which bear interest and are redeemable in cash.

In addition, to provide for redemption for these Thrift Stamps would involve such an amount of detailed accounting and labor and expense as to impair the practicability of their use. In fact, they would be more trouble and expense to the Government possibly than they are worth.

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ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for February; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "The Structure of the Uredinium in Pucciniastrum Agrimoniae," C. A. Ludwig and C. C. Rees; "Spore Formation in Philocopra Coeruleotecta," Hally Jolivette Sax; "Selected Cycles in Gymnoconia Peckiana," George F. Atkinson; "Aspergillus Fumigatus, A. Nidulans, A. Terreus N. Sp., and Their Allies," Charles Thom and Margaret B. Church.

American Mathematical Monthly, for March; *27 King St., Oberlin, Ohio; $3.00 per year:* "Rabbi Ben Ezra and the Hindu-Arabic Problem," D. E. Smith and J. Ginsburg; "The Theory of Similar Figures," Roger A. Johnson; "Note on a Certain Class of Determinants," W. H. Metzler.

Geographical Review, for March; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "Polynesian Navigators: Their Exploration and Settlement of the Pacific," Elsdon Best; "Notes on MacMillan's Ellesmere Island Trip," (twelve photos); "Modern Iceland" (five photos), Godmunder Kamban; "Some Interesting Geographical Problems in the Exploration of Northern Canada" (two photos), Charles Camsell; "The Racial History of the British People," (two maps), H. J. Fleure.

Journal of Geography, for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Montana," Grant E. Finch; "The Weather Factor in the Great War: VIII," Robert De C. Ward; "Geography Made Real by Field Study," Jennie Hall; "Some Results of the Location of Australia," S. S. Visher; "The Origin of Petroleum Pools," Edward Steidtmann.

Popular Astronomy, for April; *Northfield, Minn.; $3.50 per year:* "An Account of the Rise of Navigation," R. H. Curtiss; "What Was the Star of Bethlehem?" (continued), Stansbury Hagar; "The Zenith Equatorial," William H. Pickering; "Daylight Seeing," William H. Pickering; "In Fickle April's Firmament," Charles Nevers Holmes; "Hubble's Variable Nebula in Monoceros" (with Plate XI), C. O. Lampland.

Physical Review, for March; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Magnetization of Iron in the Absence of Hysteresis," Winthrop R. Wright; "The Ionization Potential of Mercury Vapor," T. C. Hebb; "On Equilibrium under Non-Hydrostatic Stress," P. W. Bridgman; "Elasticity of Impact of Electrons with Gas Molecules," J. M. Benade and K. T. Compton; "The Use of Mercury Droplets in Millikan's Experiment," John B. Derieux; "The Optical Properties of Rubidium," J. B. Nathanson; "The Theory of Ionization by Collision. IV. Cases of Elastic and Partially Elastic Impact," K. T. Compton and J. M. Benade.

Popular Science Monthly, for April, *225 West Thirty-Ninth St., New York City; $1.50 per year:* "The Eyes in the Air," Henry Bruno; "Submersible Forts to Protect Our Coasts;" "Hiding Ships with Paint," Robert G. Skerrett; "Dropping Death from the Skies," Carl Dienitbach; "King Weather Rules the World"; "Our Annual Coal Drama," Lloyd E. Darling; "Dealing Death with Depth Bombs," Lloyd E. Darling.

Psychological Clinic, for March; *Woodland Ave. and Thirty-Sixth St., Philadelphia; $1.50 per year, 15 cents a copy:* "Preliminary Impressions of the Stanford Revision of the Binet-Simon Scale," J. E. Wallace Wallin; "A Study of One Hundred Retarded Fourth-Grade Pupils Tested by the Binet Scale," William I. Lacy.

School Review, for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Need of a Constructive Social Program for the High School," Olivia Pound; "High School Observation Work," C. O. Davis; "The Correlation of the Professional Training with the Teaching Success of Normal School Graduates," Floyd E. Moody; "The Need of Broad-Guage Courses in Geography," R. H. Whitbeck.

School World, for March; *Macmillan Company, London, Eng.; ?s. 6d. per year:* "The Arithmetic of Citizenship," T. Percy Nunn; "Descriptive Astronomy in 'Science For All' Classes," Rev. A. L. Cortie; "Geographical Aspects of the Channel Tunnel," Francis Fox.

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DESTROY THE BARBERRY.

The common barberry is a menace to cereal crops in that it harbors one stage of the black stem rust. This rust is estimated to have caused a loss of $205,000,000 in this country in 1916. Secretary of Agriculture Houston has requested each state governor to do everything possible to reduce this loss by spreading information concerning the relation between the barberry and wheat rust. While the total eradication of the barberry would not entirely eliminate the rust of cereals, there is no question that such a measure would greatly reduce the rust. A commission for aiding in the dissemination of knowledge concerning the part the barberry plays in increasing the loss from rust has been organized in Illinois. It is also its purpose to urge all patriotic citizens to destroy the common barberry on their lands. This is especially important in the region north of Kankakee. The value of the barberry is so insignificant compared with the great food value of our cereal crops that no one should hesitate to make this sacrifice. In Denmark, where the barberry was outlawed a number of years ago, there has been a decided decrease in the amount of rust.

The Japanese barberry does not harbor the rust. This species may be distinguished from the European or common barberry as follows:

Japanese Barberry	Common (European) Barberry
(Does not harbor rust)	(Harbors rust)
Edge of leaf smooth.	Edge of leaf saw-toothed.
Twigs of last year reddish-brown.	Twigs of last year dun or grey.
Berries single or rarely in groups of two or three.	Berries in a cluster on one main stem.

EXPLOITATION OF NEGLECTED AQUATIC RESOURCES.

The history of the establishment of the tilefish fishery is well known. Up to the end of the fiscal year 1916, when the fishery was only eight months old, there had been caught and sold over 4,388,000 pounds of tilefish, for which the fishermen received more than $210,000. By the end of the first twelve months, the catch was upward of 10,250,000 pounds, selling for more than $400,000. During the fiscal year 1917, the landings aggregated 11,641,500 pounds, and the receipts of the fishermen exceeded $477,000. The headquarters of the fishery are New York and Boston.

The campaign to make an asset out of a confirmed nuisance in the form of the grayfish has progressed rapidly, and on the whole satisfactorily. Difficulties in the way of making this fish available and acceptable as human food have been overcome, and there is now an established industry on both Atlantic and Pacific coasts in canning, salting, and smoking grayfish.

Other more or less neglected fishes whose utilization has been advocated and otherwise aided by the Bureau are the sablefish of the northwest coast, burbot of the Great Lakes, and bowfin of the interior waters generally.

The scarcity of mammal hides for use in making leather has brought into prominence the value for this purpose of the skins of sharks and other aquatic creatures. Through the activities of the Bureau in behalf of fishermen and tanners, a market for such skins has been developed, and leather of a very good grade for certain industrial uses is now being made from this hitherto neglected source of supply. The general utilization of sharks for their meat and skins will have the effect of increasing the abundance of other fishes by reducing the numbers of their most destructive enemies.

Propagation of Food Fishes.

The year's work in fish culture was attended with conspicuous success.

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The output of the hatcheries was larger than in any previous year, and for the first time passed the five billion mark. There were operated fifty-five regularly established hatcheries, nineteen subhatcheries, and seventy-four egg-collecting stations. Increased efficiency and the larger volume of work reduced the unit cost of operations to the lowest point so far attained, namely, $114 per million fish produced and planted, this amount covering all overhead charges, including salaries of administrative and clerical force in Washington.

Large quantities of fish eggs were donated to the various state fish commissions for hatching and planting under local auspices.

The distribution of the hatchery output by special fish cars and detached messengers required 138,717 miles of railroad travel by cars, and 645,721 miles of railroad travel by messengers carrying fish in baggage cars. The fish were distributed to waters in every state and Alaska.

FRESH-WATER MUSSEL PROPAGATION.

With headquarters at Fairport, Iowa, on the Mississippi River, extensive work has been conducted in the Mississippi and tributaries, addressed to the pearly mussels which support a very extensive button industry. In this fascinating branch of the Bureau's work, larval mussels are inoculated on the common fishes of the region, and the fishes are then liberated in open waters. After a time the young mussels drop off the fishes and begin their independent existence on the bottom. Buttons have been made from mussels grown from the microscopic larvae to full-sized adults in the ponds of the fishery laboratory at Fairport.

ANTIFREEZING SOLUTIONS FOR AUTOMOBILE RADIATORS.

The subject of antifreezing solutions for automobile radiators has been brought very forcibly to the attention of users of motor vehicles this winter, and many requests for information regarding their use have been received by the Bureau of Standards, Department of Commerce. An investigation was undertaken by the Bureau to establish the value of these compounds, and sufficient data have recently been obtained to justify a preliminary statement. This work will be continued, tests equivalent to service conditions will be made, and a more comprehensive report given at a later date, but in time for use during the coming winter.

A careful study of this question by the Bureau leads to the conclusions based on experiment that, (1) calcium chloride compounds should be used with caution, if at all, on account of their corrosive action; (2) kerosene or similar oils should not be used on account of their inflammability, high boiling point, and effect on rubber; (3) mixtures of glycerine and alcohol can be used, but the price of glycerine and the need for it in the manufacture of munitions at the present time should preclude its use; (4) solutions made from either wood alcohol or denatured alcohol seem at the present time to be the most desirable antifreezing solutions to use. If the wood alcohol is free from acid there is little choice between the two alcohols. Wood alcohol costs more than denatured alcohol and is more volatile, but its lower freezing point allows a less amount to be used, which may counteract the above disadvantage.

The ideal antifreezing compound is one that will prevent freezing of the radiator liquid without injuring either engine or radiator, that will not lose its non-freezing properties after continued use, and that does not materially change the boiling point of water when dissolved in it.

KINDS OF ANTIFREEZING COMPOUNDS.

There are two general types of these compounds—one a solution in water of alcohol or glycerine, or of a mixture of the latter two, the other a solution in water of calcium chloride or the dry salt itself, which con-

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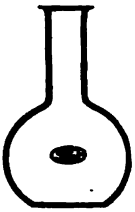

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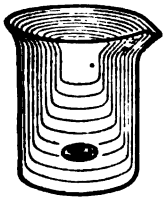

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The Bureau of Chemistry has made considerable progress in demonstrating the processes devised by it for preparing sugar-cane and sorghum sirup that will not crystallize or ferment, and for utilizing the by-products. The work already under way on methods of handling, packing, storing, shipping, and utilizing fish, in order to make the supply more immediately available for food, has been extended and developed. In connection with the efforts to increase the supply of poultry and eggs, plans have been made to stimulate the establishment of poultry and egg packing plants in accordance with the principles worked out by the Food Research Laboratory. Ten additional men are being assigned to this work.

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tains sometimes small amounts of other substances such as salt, sal ammoniac, sugar, or syrup. Kerosene and similar oils, without admixture, are sometimes used.

Kerosene.

Kerosene has a lower freezing point and higher boiling point than water, but the inflammability of its vapor makes it dangerous to use, and its high and uncertain boiling point might lead to the serious overheating of the engine, or even to the melting of the solder in the radiator. It has a marked solvent action on rubber parts. These facts would seem to clearly indicate that this material should not be used.

Alcohol and Calcium Chloride.

The alcohol-water type is the most common, and is not generally sold under any trade name, but recently there have appeared on the market a number of antifreezing compounds of the calcium chloride type. These compounds are sold under a variety of names, and startling claims are made for their effectiveness and lack of injurious effects.

Corrosive Action. The alcohol solutions do not exert a greater corrosive action than water alone. This can be predicted from theoretical considerations and is well established in practice. However, wood alcohol sometimes contains free acid, such as acetic acid, which is objectionable, and for this reason wood alcohol should be used only when it is known to be free from acids.

The calcium chloride compounds exert a greater corrosive action than water on the engine jacket, on the solder in the radiator, and on aluminum which is sometimes used in manifolds, pumps, and headers. The effect on engine jackets may be neglected since these are generally sufficiently heavy to permit considerable corrosion without being weakened. The effect on soldered joints may be serious, since tests made at the Bureau of Standards have shown the complete removal of solder from copper and brass when immersed in a hot twenty per cent calcium chloride solution for four days. A number of such tests were made, and there was always a more rapid corrosion or eating away of solder in these antifreezing compounds than in water.

Calcium Chloride and Ignition. Another troublesome effect of calcium chloride solutions is experienced if small leaks occur in the radiator, the water jackets, or connections, and the solution comes in contact with the spark plugs and ignition wires. In some cases the drops of the solution may be carried back on the engine in a more or less atomized state, assisted by the fan when running. The salt deposited when the water evaporates is very difficult to remove, and when it cools absorbs water and becomes a good electrical conductor, short-circuiting the spark plugs and sometimes making it impossible to start the engine. The difficulty may disappear when the engine is heated up.

There are also certain conditions in the manufacture of calcium chloride which may result in a compound that will deposit large crystals in the radiator as the solution cools; this may prevent effective circulation.

Calcium Chloride Has Been Used. Regardless of these objections, reports have been received to the effect that calcium chloride solutions have been used a number of years in the same radiator without producing apparent corrosion. Nevertheless, such solutions cannot be recommended as safe, and they should not be used if there is any aluminum in the cooling system.

The chief advantage of calcium chloride compounds is that they are not volatile. The solutions can be kept practically uniform by adding water from time to time. Unfortunately, this is not true with the alcohol solutions, because the alcohol continually boils out and it must be re-

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Most of the experiments as described are very simple and most of the apparatus required is inexpensive, and the authors believe that the book will be very helpful to the teacher of physics in the High School.

An important feature of the book is an Appendix on *A Visitors' Laboratory of Physics* in which suggestions are made for the setting up permanently of about 80 experiments for the edification of visitors. The authors believe that this phase of the museum idea should be developed in every High School.

Another feature of the book is an extremely simple and clear setting forth of the fundamental ideas of mechanics; and the authors make use of every opportunity to illuminate the problems of the teacher, and they do this in a way that will certainly entertain the reader and, as the authors believe, also edify him.

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placed frequently in order to maintain the proper proportion of alcohol. Glycerine is frequently substituted for part of the alcohol to reduce evaporation, but when glycerine is used the rubber connections may be affected somewhat seriously, depending on the quality of the rubber. The most practical method to maintian the proper quantity of alcohol in the solution is to determine the specific gravity of the liquid by means of a hydrometer and by reference to a table add the necessary quantity of alcohol to obtain the desired gravity.

This table and a statement regarding the use of a hydrometer can be obtained by application to the Director, Bureau of Standards, Washington, D. C.

PRICE OF COMPOUNDS. The price of these compounds is of decided interest. The retail price of denatured alcohol is more or less definitely fixed by its cost of production and the prevailing market conditions. Calcium chloride is a by-product from certain manufacturing industries, and is sold at less than two cents per pound, wholesale. However, when properly packed and labeled it is sold to automobile users as an antifreezing compound at the rate of twenty-five to fifty cents per pound, an increase of between one thousand to two thousand per cent.

Without approving the use of a calcium chloride solution as an antifreezing solution, it may be said that a homemade solution of calcium chloride can be prepared at a cost less than one-half the retail price at which such antifreezing compounds are sold, by buying calcium chloride in the open market and dissolving it in water.

CANNEL COAL.

Cannel coal has long been a will-o'-the-wisp to coal men, and to many of them its mere mention brings up visions of wealth. The reason becomes obvious when its price on the market is compared with that of ordinary bituminous coal, for in days past cannel coal has sold in the New York market at a price about three times that of the best bituminous coal and perhaps double the price of anthracite. This high price is due to old causes—strong demand and weak supply.

As a coal for use in office and household grates, as an enricher of coal gas, and as a quick-firing coal for use in fire engines and otherwise, cannel coal has filled a unique place; and these uses coupled with its scarcity in the earth have made it an object of much search and of many disappointments, because wherever it is found there has usually proved to be very little of it.

Of late years, however, fewer grates are used in the office and the home, and water gas, enriched with oil, has replaced the old type of coal gas, so that when the European war broke out the demand for cannel coal as such had largely disappeared. Then some people remembered that many years ago, before oil was struck in the country, houses were lighted with oil obtained from cannel coal. They remembered that on distillation cannel coal yielded more oil and gas than could be obtained from ordinary bituminous coal. They realized that the sudden demand for high explosives for use in the war required the utilization of the by-products formed in the distillation of coal, and they argued that if cannel coal when distilled yielded more oil and gas than other coals it should be very rich in the by-products from which benzene, toluol, and other explosive bases are made, so a demand was made for information about cannel coal. To supply this information the Government, through the Geological Survey, Department of the Interior, has just issued a report on the cannel coals of the United States, describing cannel coal in detail and telling where it can be found. This report refers to every place where cannel coal has been

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found or where it is said to occur. It contains references to nearly a hundred and fifty such places in one state alone, Kentucky.

The fact that cannel coal does yield large quantities of oil and gas is confirmed, but it is found that this oil, though suitable for ordinary burning, distills at a temperature so low that the percentage of gasoline, benzene, and other desired substances it contains is very small, and until some way has been discovered of distilling it at a higher temperature or of cracking or otherwise converting the oils found into the oils desired, the distillation of cannel coal will not furnish the large supply of gasoline, benzene, toluol, and other substances that are now so greatly needed.—[*U. S. Geological Survey Press Bulletin.*

A SUGGESTIVE APPROACH TO THE USE OF THE FUNCTIONAL NOTATION.

By L. E. Lunn,
Heron Lake, Minn.

In some of our newer texts there is an acknowledgment of the generally felt want for an earlier introduction to the notion of a function. This is rightly so as the use of the functional notation is one of the stumbling-blocks of the freshman in the collegiate courses in mathematics. The idea of function is the next great mathematical advance that the student makes after grasping the idea of general number.

In using Mr. Breslich's *Third Year of Mathematics*, I have been struck with the idea of using the functional idea in the solution of certain types of quadratic equations.

For instance, we have equations of the following nature:

1. $(x+3)^2-5(x+3)-24 = 0.$
2. $x^2+5x-3+8(x^2+5x-3)^{1/2} = 15.$
3. $\tan^2 y+3\tan y = 4.$

These equations are all conveniently written,

1. $f^2(x)-5f(x)-24 = 0.$
2. $f^2(x)+8f(x)-15 = 0.$
3. $f^2(y)+3f(y)-4 = 0.$

These are then solved for the function involved by rules of quadratic equations, and the function finally solved for the particular variable.

Of course these equations are readily handled by either mentally or actually making a literal substitution for the function involved. However, I believe that the above method is valuable to accustom students to the use of this form of notation.

COAST AND GEODETIC SURVEY ESTABLISHES SUBOFFICE AT BOSTON.

To keep more directly in touch with the interests of shipping in the waters of Maine, New Hampshire, and Massachusetts, the United States Coast and Geodetic Survey, Department of Commerce, will establish a suboffice in the Customhouse at Boston about January 1, 1918. As inspector in charge of this office, Homer P. Ritter, a commissioned officer of the Survey, will be prepared to furnish information relative to the operations of this branch of the Government service.

It will be the endeavor of this suboffice to cooperate fully with steamship lines, yacht clubs, mariners, and others to the extent that dangers discovered, changes in channels, and various other kinds of information needed by the Survey for keeping its nautical publications up to date shall be made available to the public as promptly as possible.

A complete and up-to-date file of charts and publications relating to our coasts and surveys will be available for inspection by those interested, and the office will maintain a supply of the charts and other publications of the Survey for sale at catalogue prices.

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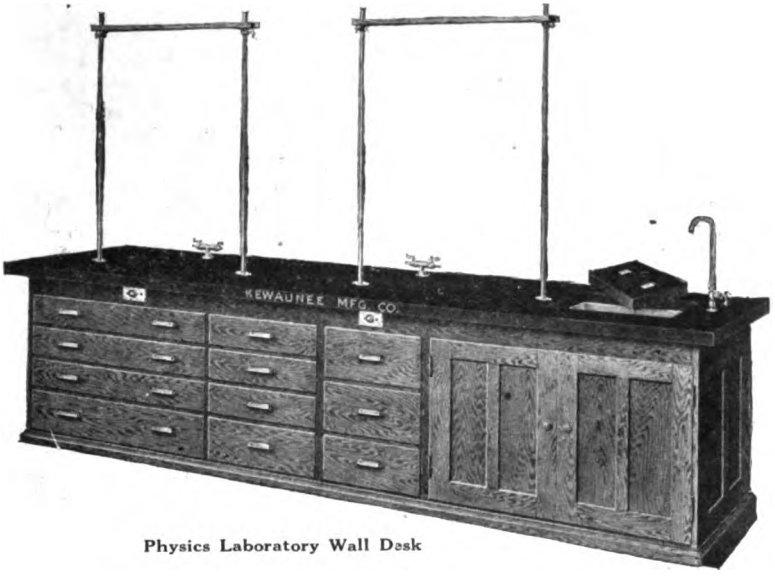

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BOOK REVIEWS.

A Laboratory Manual of General Chemistry, by William J. Hale, Associate Professor of General Chemistry in the University of Michigan. First edition. Pages xi+474. 2 1/2x13 1/2x19 1/2 cm. A few line drawings in the first part of the book. Cloth. 1917. $1.50. The Macmillan Company, New York.

This new laboratory manual is evidently intended for use with college classes in general chemistry. It presents in unusually complete and detailed form the essential parts of a well-rounded course in general chemistry. In the treatment of the metals the author makes an especial effort to present the chemistry that is later to be made use of (in formal qualitative analysis). The work thus given leads to an understanding of the methods of group separation, but does not attempt the detailed separation of the metals of the several groups. This correlation of the chemistry of the metals with that of qualitative analysis is admirable teaching. The book also contains a special chapter on the identification of negative radicals. Although regularly bound, the book has all right-hand pages left blank except that numbers are printed upon the otherwise blank pages to serve as a guide in the answering of numbered questions which accompany the directions. The object of this arrangement, according to the author, is to prevent the jotting down of helter-skelter notes.

The directions are terse, yet sufficiently complete and clear for the student of college age. F. B. W.

An Elementary Study of Chemistry, by William McPherson and William Edwards Henderson, Professors of Chemistry, Ohio State University. Second revised edition. Pages xii+576. 3x14x19 1/2 cm. Illustrated. Cloth. 1917. $1.60. Ginn & Company.

This revised edition of a text that has been well and favorably known to many teachers, brings it down to date and embodies some changes which have resulted from trials of the manuscript in actual use with classes. The illustrations are excellent. The ground covered is extensive, as the 576 pages suggest. The authors include elementary treatment of the mass law, and very complete elementary use of the theory of electrolytic dissociation. While the teaching of the principles is made the chief end of the text, there are many practical applications given as illustrations, and these add interest to the book. F. B. W.

The Cadet Manual, Official Handbook for High School Volunteers of the United States, by Major E. Z. Steever and Major J. L. Frink. 15×20 cm. Pages xxxi+317. Net, $1.50. 1918. J. B. Lippencott Co., Philadelphia.

The Cadet Manual is the outgrowth of several years' experience in training high school boys in Wyoming, Chicago, Washington, Kansas City, and elsewhere. In Wyoming Major Steever originated and successfully developed a course of high school military training that won the confidence and support of the entire state. The success of his work in Wyoming became so well known that he was asked by several of the large cities to initiate such a course of military training in their high schools.

This book appears at a most opportune time as it is now very evident that the only salvation of our country in the future is universal military training.

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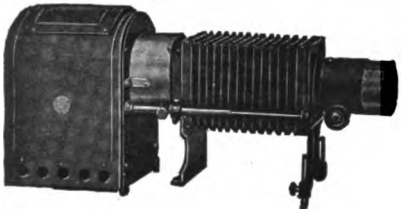

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 6 JUNE, 1918 WHOLE No. 152

THE INFLUENCE OF HIGH SCHOOL BIOLOGICAL COURSES UPON GRADES OF UNIVERSITY FRESHMEN IN ZOOLOGY.

BY H. J. VAN CLEAVE,

Department of Zoology, University of Illinois.

Attention has been called recently to the lack of influence of specific high school units upon marks of college students. Professor Charters[1] has, in a striking manner, presented facts relative to the influence of high school German upon the grades of students in a university class in the same subject. His data were from grades in a second course in German in the University of Missouri. For entrance to this course one semester of elementary German in the university or two years of high school German were required. An analysis of the distribution of the grades showed that those who offered one semester of college German received, on the average, better grades than those who had taken two years of German in high school. The results of this investigation were so suggestive that it seemed worth while to the present writer to present some data along the same general line, dealing with the correlation between high school work in biological courses and marks in a university course in zoology.

It is a common impression among college teachers of zoology that biological work done in the high schools has but little, if any, influence upon the character of the work done by students in college zoology. While this impression has been very general, there do not seem to have been many attempts either to prove the fallacy of the contention or to offer actual data in its support.

In connection with the instruction in general zoology at the University of Illinois, the writer has had opportunity of examining the records of students in university zoology in a critical manner. This subject in the institution under consideration is open to those who have had no high school zoology, as well

[1] Charters, W. W., *School and Society*, 7:119-120.

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as to those who have had a course in the high school. In fact, the two groups are not even separated into different sections of the class. By securing information regarding the amount of and nature of the high school sciences offered for entrance credit by individual students, it has been possible to make a direct comparison between the grades in college zoology made by students who have had various combinations of biological courses and those of students who have had no preparatory course in the biological sciences.

In an earlier paper the writer has shown[2] that in the course under consideration there is a striking lack of uniformity in the grade of work done by students in the various years of the college course. For this reason, chiefly, it has seemed desirable in this study to confine the attention to records of those students who have been registered in general zoology during their first year of university work. Data have been gathered covering a period of approximately three years. In another paper[3] the writer has demonstrated that the standards of grading used in this course have been sufficiently uniform to warrant the consideration of grades from various years' work being assembled in the consideration of mass data. Grades and high school records of 174 freshmen in general zoology have been brought together in the course of this study. Of these, 103 had credit for at least one-half year of high school zoology; 23 of this same group had no credit for high school botany, while the remaining 80 were students who had taken both zoology and botany in high school. Seventy-one who had earned no credit in zoology before entering the university comprised 49 who had taken neither botany nor zoology and 22 who had taken botany but no zoology.

TABLE I.—AVERAGE GRADES OF FRESHMEN IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No. of Students.	FINAL GRADE Av.	FINAL GRADE Median.	QUIZ GRADE Av.	QUIZ GRADE Median	LAB. GRADE Av.	LAB. GRADE Median
Zoology and botany	80	78	78.3	79.9	80	79.5	80
Zoology only	23	79	80	80.1	80	80.1	80
Total having zoology	**103**	**78.2**	**79**	**79.8**	**80**	**79.6**	**80**
Botany only	22	76.2	77	80.5	83	77.3	80
Neither botany nor zoology	49	75.2	75	77.2	78	76.8	78
Total having no zoology	**71**	**75.7**	**76**	**78.2**	**80**	**77**	**78**

From Table I it appears that the advantage gained by those having had high school zoology over those not having had it is practically negligible as far as influencing the final average and median grades of the two groups in university zoology is con-

[2] Van Cleave, H. J., *School and Society*, 5:356-360.
[3] Van Cleave, H. J., *Educational Administration and Supervision*, 2:251-253.

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cerned. By closer analysis of the data, bringing together those who have had similar biological training in high school, it becomes apparent that those who have taken both botany and zoology average less than three points higher in university zoology than those who have taken neither botany nor zoology in high school. This difference is unfortunately small. In fact, it is so small a difference that any method of expression other than an arithmetical average of per cent grades would classify these two groups of students as doing work of equal merit, regardless of their difference in previous training. In general, the same lack of sharp separation between the two groups applies to the average grades in both laboratory and quiz.

In an earlier paper,[2] referred to above, the writer has demonstrated that students may show broadly varying degrees of proficiency in laboratory work and in oral quiz. Of these the latter is based chiefly upon content of lectures and text assignments, and consequently does not involve the exercise of many of the operations and procedures which are peculiar to the biological sciences. If high school work in zoology provides a training in scientific method and laboratory manipulation, the results of this training should be reflected in the superior laboratory work of students in the university who have had biological training in their preparatory course. An inspection of Table I shows that the average laboratory grade of these students excels that of students who have had no zoology before entering the university by only 2.6 points. That this slight difference is not due to the effect of a few exceptionally low or high marks in either group is demonstrated by the fact that the median grades in the two groups differ by but two points. What is even more unexpected is the fact that those who had had no previous training in the laboratory methods peculiar to biology averaged less than three points lower in laboratory grades than did those who had taken courses in both zoology and botany.

TABLE II.—PERCENTAGES OF FRESHMEN HAVING AVERAGES BELOW 70 IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No. of Students.	Per Cent Failure in Course.	Per Cent Below 70 In Quiz.	Per Cent Below 70. In Lab.
Zoology and botany	80	11.3	7.5	7.5
Zoology only	23	13	8.7	13
Total having zoology	**103**	**11.7**	**7.8**	**8.7**
Botany only	22	13.6	0	19
Neither botany nor zoology	49	20.4	20.4	12.8
Total having no zoology	**71**	**18.3**	**14.1**	**14.1**

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In connection with the foregoing table it should be mentioned that 70 is considered the passing grade.

On the evidence presented in Table I there seems to be justification of the common impression that those who have had high school zoology do little if any better in the university zoology than those who have had no such course previously. However, a closer analysis of the data as given in Tables II, III, and IV and in Figures 1, 2, and 3 furnishes evidence that there are real differences in the two groups which a mathematical average of the grades fails to bring out. For example, it is quite significant that the total failures in university zoology (Table II) should include but 11.3 per cent of those who have taken both botany and zoology in high school, and 20.4 per cent of those who have taken no high school course in either zoology or botany.

Whether this indicates a difference in ability due to actual increased proficiency in methods and manipulation or is simply the result of eliminating from the university course those who did poorly in biological courses of the high school, remains unproven. A comparison of the percentages of those below 70 in laboratory and in quiz indicates, however, that there is very little difference between the percentages of failure in these two phases of the work.

On the supposition that one might expect to find increased proficiency in laboratory work resulting from experience gained in the high school courses in biology it is hard to explain how 20.4 per cent of those who had neither botany nor zoology in high school did unsatisfactory work in quiz, while but 12.8 per cent of the same group were unsatisfactory laboratory students. Of those who had taken zoology in high school a slightly larger percentage did unsatisfactory work in laboratory (8.7 per cent) than in quiz (7.8 per cent). These results are contrary to the expectation voiced in the opening of this paragraph.

The question arises as to the influence of high school botany upon the character of the work done by students in university zoology. The number of instances wherein students took botany and no zoology in the present study is far too small to be of any great consequence toward establishing the existence of or absence of correlation between methods in the two subjects. The fact remains that of the 22 students who took botany and no zoology in high school, none failed in quiz while 19 per cent

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failed in the laboratory phase of the university zoology. That these same students averaged higher in quiz than in laboratory would at least suggest that they did not carry over any great amount of laboratory method from the one science to the other.

TABLE III.—PERCENTAGES OF FRESHMEN HAVING AVERAGE GRADES OF 90 OR ABOVE IN UNIVERSITY ZOOLOGY.

Biological Courses in High School.	No of Students.	Per Cent with Grade of 90 or Above: Final Grade.	Quiz.	Laboratory.
Zoology and botany	80	13.8	16.3	10
Zoology only	23	8.7	8.7	13
Total having zoology	**103**	**12.6**	**14.6**	**10.7**
Botany only	22	9.1	13.6	13.6
Neither botany nor zoology	49	8.2	16.3	0
Total having no zoology	**71**	**8.5**	**15.5**	**5.6**

Taking students who received a final grade of 90 or above as indicating those who did superior work in the entire course (see Table III), 13.8 per cent of those who had both zoology and botany in the high school fall in this group, while only 8.2 per cent of those who had neither zoology nor botany in high school could be classified here. Among these students receiving the highest grades there is an increased ability in laboratory work, apparently due to the high school training, for in the case under consideration 10.7 per cent of those who had taken zoology in high school did laboratory work with a grade of 90 or better in the university, while *no* student among the university freshmen who had taken neither zoology nor botany in high school succeeded in getting a grade of 90 in his laboratory work.

It is rather remarkable that those who had taken a full year of high school zoology did but little better in the university course than the average of all those who had taken any zoology in high school, the majority of whom had taken it for but half a year. From figures not given in the tables it has been determined that the average final grade in university zoology of 24 freshmen who had taken a full year of the subject in high school was 80.5. This means that a full year devoted to zoology in the high school raised the final grade in university zoology only five points above the average for persons having no previous training whatsoever in biological sciences.

A system of literal grades has recently replaced the numerical grading system in the University of Illinois. By a statistical study involving the grades of over 1,000 students who, in the

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past five years, have taken the elementary course in zoology, the writer has determined the approximate equivalence of numerical and literal grades for this course. The numerical values assigned to the literal symbols were such that A (Excellent) included about the upper 10 per cent of the entire group of students; B (Good) included the next 30 per cent; C (Fair) about 35 per cent; D (Poor) a small group of about 15 per cent; and E (Failure) about 10 per cent.

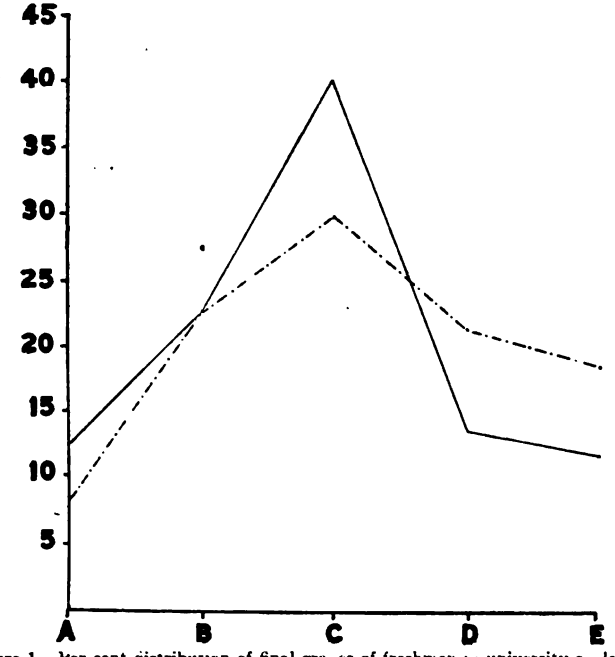

Figure 1. Per cent distribution of final grades of freshmen in university zoology. Solid line represents distribution of final grades of 103 freshmen who had taken high school zoology. Dot and dash line, distribution of final grades of 71 freshmen who had taken no zoology in high school.

TABLE IV.—PER CENT DISTRIBUTION OF GRADES OF UNIVERSITY FRESHMEN IN ZOOLOGY.

	Per Cent A (Excellent)	Per Cent B (Good)	Per Cent C (Fair)	Per Cent D (Poor)	Per Cent E (Failure)
Quiz Grades:					
High school zoology	14.6	24.3	41.7	11.6	7.8
No high school zoology	15.5	22.5	33.8	14.1	14.1
Laboratory Grades:					
High school zoology	10.7	23.3	44.7	12.6	8.7
No high school zoology	5.6	25.3	42.3	12.7	14.1
Final Grades:					
High school zoology	12.6	22.3	39.8	13.6	11.7
No high school zoology	8.5	22.5	29.6	21.1	18.3

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These literal grades more nearly conform to a natural classification or grouping of students of like ability without placing undue emphasis upon differences of a few per cent. In fact, such slight differences are immeasurable in actual practice of grading. Table IV shows the distribution of the grades under consideration in this paper on the basis of the literal system.

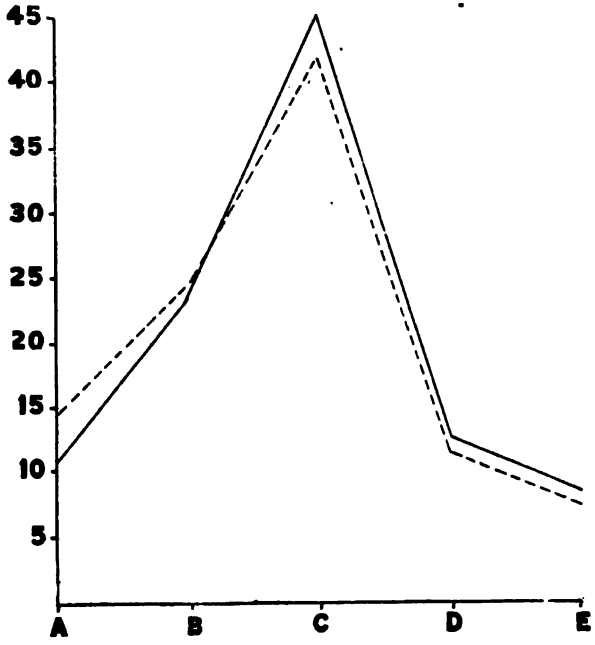

Figure 2. Per cent distribution of laboratory and quiz grades in university zoology for 103 freshmen who had taken zoology in high school. Solid line represents distribution of grades in laboratory; broken line, grades in quiz.

For ready comparison of the grades the data presented in Table IV have been prepared as a series of graphs (Figures 1, 2, and 3). In each of these graphs the scale upon the abscissa represents the literal grades, while the scale upon the ordinate represents the percentage of students in the different groups receiving the grades indicated upon the abscissa.

In spite of the fact that the average final grades for those who had and for those who had not taken high school zoology differed so slightly, the curves for these two groups show that this difference is distributed throughout almost the entire length of the curves.

Figure 2 emphasizes in graphic manner the lack of measurable increased ability in laboratory over quiz resulting from the pursuit of zoology in the high school.

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Figure 3 shows that while few students without previous training in the subject were able to do 'excellent' laboratory work, the averages in laboratory throughout the remainder of the group were better than the averages in quiz.

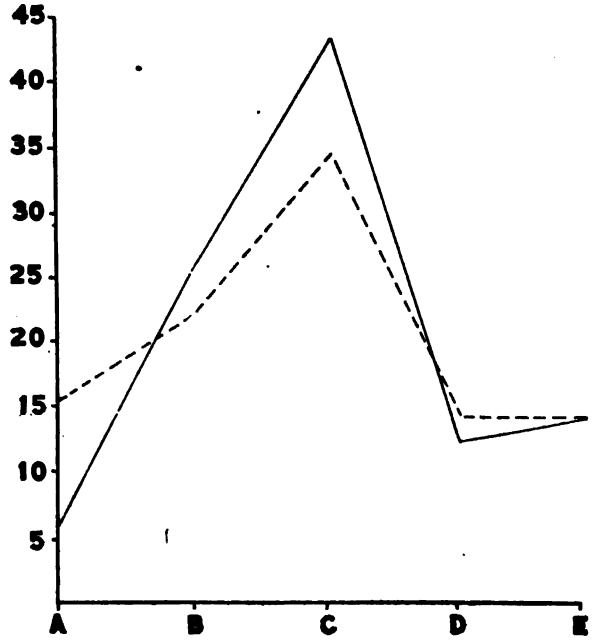

Figure 3. Per cent distribution of laboratory and quiz grades in university zoology for 71 freshmen who had taken no zoology in high school. Solid line, grades in laboratory; broken line, grades in quiz.

CONCLUSIONS.

From facts brought out in this paper it may be concluded that the average final grade of freshmen in university zoology is little affected by previous training in biological courses. Taken alone this seems to corroborate an opinion frequently expressed by college and university teachers of zoology, namely, that the study of or omission of zoology in high school has little influence upon the kind of work done by students in this same subject in college or university classes.

As a matter of fact, while the actual difference in average and median final grades in university zoology of students having and those not having high school zoology is slight, it is none the less real since the advantage is distributed among practically all groups of students who have had work in high school biological courses.

The relatively small difference between these two groups of

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students indicates in a forceful manner the result of the lack of coordination between high school and university courses in zoology and botany. The majority of those interested in the teaching of the biological sciences realize that there is a lack of standardization of zoology and botany courses in the secondary schools. This lack of standardization is in great measure responsible for the lack of coordination just mentioned. Under these conditions students entering institutions of higher learning have had such varied training in zoology or in botany that usually no attempt has been made to give recognition to the start which they have made in biological work. It is sometimes argued that the greater or less amount of repetition which this procedure involves has an undesirable influence upon the attitude of the students toward their work in the university course. Granted that this may be true, it does not explain why those who have had biological courses in high school show almost negligible increased proficiency in laboratory methods. In fact, an examination of Figures 2 and 3 shows that these students do laboratory and quiz work of practically identical grade, while those who have had no high school zoology produce greater numbers who receive better grades in laboratory than in quiz.

This lack of specific training in scientific methods which in the laboratory work of the biological sciences involves rather distinct types of manipulation and procedure is a point wherein the high school courses in zoology and botany apparently fail to give the training in scientific method which may be logically expected from them.

In connection with these conclusions there are certain facts which must be kept in mind. The writer has considered only the influence of high school biological courses upon *grades* received by university freshmen in zoology. This influence in itself must not be regarded as a measure of the success or failure of biological courses as given in the secondary schools. As brought out earlier in this paper, the lack of specific influence of these subjects upon the grade of work done in the same subjects in university is due in great measure to the lack of correlation between the high school and university courses in biology. The percentage of high school students which goes on into university work is so small that it does not seem expedient that an absolute correlation should be sought. The ultimate aim of high school zoology should be the fitting of its students for better living and greater service to society.

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BOTANY LABORATORY EQUIPMENT.

By Willard N. Clute,
Joliet, Ill.

Something seems to be the matter with botany. On all sides we are told that the study meets no real need of the pupil, that its place in the curriculum might better be given to more practical things, and that it is only a matter of time, anyway, until it will come to an end through sheer inanition. A decrease of nearly 50 per cent in registration in the study during the last ten years gives point to these assertions and inclines the advocate of botany in the schools to sit up and take notice.

It is no secret that botany, as taught at present, is fast waning in popularity. The reason for this decline in interest has been sought in various directions without securing any very satisfactory answer. Some explain the situation by the statement that there has been a tremendous shift from botany to agriculture, general science, manual training, and domestic science, but, to my mind, this does not entirely account for the situation. Though the studies mentioned are still so new as to possess the charm of novelty, it is not, I am sure, the novelty alone that attracts. The fact that they present certain phases of education in a more practical way, or at least emphasize the practical aspects of certain studies, has a strong appeal for the pupil. The intelligent student is more than ever inclined to ask what advantages a given course of study will bring him, and, if the advantages are not apparent, to drop it from his list. Botany seems to be one of the studies that have been tried and found wanting. The question then is, what are we going to do about it?

One of the first things that can be done to rehabilitate botany is to give it a more practical turn. There are, to be sure, a number of schools in which the study already has this character but the statement that botany is as yet rather too academic and lacking in practical applications is not likely to be seriously challenged. Too many botany classes are still engaged in the "analysis" of flowers and in herbarium making. Others are giving altogether too much time to the minute anatomy of plants, to the microscopic study of the blue-green algae; to the morphology of mosses and ferns, the alternation of generations, the evolution of spermatophytes, and various other matters that might better be left to the kindly ministrations of college and university.

In citing the studies just mentioned as examples, no criticism

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is made of their cultural value. If botany is to continue to be mainly a cultural subject, possibly we should continue to emphasize them, but the teacher of botany is confronted by the stubborn fact that these things do not appeal to the general public. If they did, botany would not be losing ground. What the public wants,—nay, is beginning to demand—is more information regarding foods, fibers, drugs, dyes, woods, and other useful plant products, budding, grafting, plant breeding, Mendel's Law, the adjustments of plants to soil and climate—in short, it wants information on those phases of botany that touch community life, and there does not seem any valid reason why it should not have such information though there are a number of reasons why it does not get it.

One reason for the unpopularity of the course in botany is to be found in the books on the subject. Practically all of these are written by college men; estimable gentlemen, all, but men, nevertheless, who know mighty little about what the public wants (judged by their works) and who, I sometimes suspect, care less. Most of them have been so long out of touch with the youngster of fourteen that the very language they use is not intelligible to him. Nor is the subject presented in such a way as to interest him. It is not contended that children cannot be made to take on enough of the matter provided to pass a creditable examination, but if anybody wants data on how deep such information sinks in, let him inquire how many students of botany are enough impressed with it to continue it after they have left school. The real botanists and botanizers of our country—people who are enough interested in botany to make it an avocation—did not, as a rule, take botany in the schools!

I would be the last person in the world to charge any of the shortcomings of the botanical course to the teachers. In my opinion, they are the most devoted, self-sacrificing and energetic group of people in the schools today. What other teachers, after a full day's work, contribute so much of their time and money to the hunt for specimens to be used in class next day? The teacher of manual training has a well-equipped shop stocked with the materials of his trade; the domestic science teacher is likewise supplied with everything needed by her classes except certain perishables which can be ordered by telephone; the teacher of agriculture is provided with seeds, tools, charts, land, and a laboratory, but the botany teacher still collects his own

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materials—or goes without. With the best intentions in the world, the botany teacher is his own greatest enemy. He has rustled for himself so long that boards of education are disposed to let him continue it. Is it any wonder, then, that dried and pickled specimens form the backbone of most botanical courses?

Even the botany teacher often fails to see that his study, with zoology, is sharply set off from all others by the fact that it deals with *living things*. These have their youth, maturity, and old age, their time of growth and of reproduction. They cannot be kept in bottles on the shelf like the materials of the chemist. They must not only be accessible in the living state, but means must be found to have them in the proper condition of maturity required. There should be a collection of plants growing in the open, supplemented by a greenhouse in which various exotics may be cultivated for study in winter. A practical course would also require a museum of various plant products. Of course all these things cost money, but before deciding that they cost more than the school can afford, compare their cost with the expense incurred in fitting up the manual training department, the chemistry or physics laboratory, or the gymnasium. And last, frequent field trips must be conducted if real botany is to be taught. The arrangement of plants in greenhouse and garden is at best artificial. The student needs to see plants as they grow in the wild. I imagine that if the botanical course were adequately equipped and properly manned, we would hear less about the decline in botany. Every teacher who desires the advancement of botanical teaching should consider himself a committee of one to push the claims of botany to an adequate equipment.

And, finally, the teacher of botany should keep a sharp watch on certain phases of general science. Any course in the latter which skims the cream from botany and gives the pupil the impression that he has had botany is a menace. If general science remains *general* science, it will be a help and worthy of encouragement. Properly presented in the first year it will relieve the teacher of a large amount of instruction in the principles upon which his science is founded, but if this study is allowed to arrogate to itself instruction in the elements of botany, then our sorely beset science will the sooner follow the lepidodendron and the cycadofilices into oblivion.

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BIOLOGY IN THE HIGH SCHOOL OF TOMORROW.[1]

By Harold B. Shinn,

Schurz High School, Chicago.

One well acquainted with modern schools and school-teachers recently remarked that altogether too often discussion of a school question dropped into unkind and destructive criticism of everything and everybody. We grant this statement, and, having granted it, stand ready to look, not backward to a condition of mental servitude and hero worship, but ahead to a promised land, an immediate future out of which we hope to secure at least a few good things for biology in the high school of today. There are so many factors in the problem of teaching biology that one must analyze them and work from smaller details to larger generalizations.

Those of us who have been watching the changes occurring in viewpoint, motive, or aim are saying that probably the question soon to surge upon us is, "How can we help save human life, and, having saved it, how make living more worth while?" A college man well known for his chemical researches once said to me: "The man who undertakes a research problem which will contribute nothing to better human conditions is a parasite upon society." This statement seemed the more surprising because of him who said it. Biology is going to cut out many topics which contributed little or nothing to human welfare and human happiness in order that it may elaborate others. And those teachers who fail to get this viewpoint will be relegated to the scrap heap. We maintain that in a high school course there is no room for long-winded discussions of the algae, red, green, blue-green, and brown; for taxonomy of ferns and mosses; for anything of echinoderms nor more than cursory treatment of coelenterates; for the fruitless dissection of many forms. In botany there will be more of the planting and care of house plants and grounds, more studies in the ecology of those plants and animals which appear in the landscape and contribute to it, and more study and care of home and farm.

We feel sure that even yet, after several years of "economic" teaching of plants and animals, there remains in the minds of many teachers of academic thought a marked dislike for the word and its use; and we are equally sure that this dislike is caused by the narrow treatment of so-called "economic" forms

[1]Read at the November, 1917, meeting of the Central Association at Columbus, Ohio.

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by accepted textbooks. The cabbage butterfly, for example, is truly a noxious insect, yet it illustrates all that any butterfly shows—coloration and sex markings, metamorphosis, dispersal, etc., so that perfectly good zoology can be taught with an injurious form. Textbooks, however, still teach zoology from the poor old locust, who has been so sadly overworked, and set the cabbage butterfly over to a chapter prefaced with a statement of how many million dollars' worth of damage it does annually.

The corn plant is botanical material with a strongly mercenary association, yet it is capable of just as extended treatment as was Huxley's crayfish, which was used for an entire year in his classes. The corn can be utilized to teach the phenomena of soil conditions, growth, food storage, cross- and self-pollination, and seed structure, botany fully as good as that of the lily or the pine. But the corn and all the cereals are usually set back in the book to a chapter prefaced with a statement of the cash value of the various cereals in 1900 B. C. Corn and the cabbage butterfly are but illustrations of a fairly general state of affairs in biology. Yet as educators we stoutly maintain that just as good mental training can be gained from the study of a science, which is sometimes practical, as from the study of a dead and moldy language, which was never very practical but was the hall mark of a scholar.

Therefore there should arise no misunderstanding as to motive. Biology will be economic but not mercenary; its subjects will be taught, not because they add a dollar to nor subtract a dollar from the future income of tomorrow's pupils, but because they will add to the joy and the possibility of living. The commercial courses of today are not educational because their ideal is the dollar. Our motive will be higher than most of us conceive in the word economic; the spirit of altruism and community service will give a deeper life to biology.

With the new viewpoint botany will teach, and should now teach, the principles of soil fertilization, sterilization, and innoculation. There will be more practical work with plants, as forestry, tree planting and tree surgery, pruning, grafting, budding, artificial pollination, and breeding. There will be a wider use of the indoor garden; home gardening and work in the fields will be directed by the school and will be accredited in the botany course, as it is now in many progressive schools. Indeed, the summer vacation will bring, to some extent, merely

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a change in laboratory. Briefly, in botany tomorrow there will be less of the book and more of the plant.

In zoology the study of invertebrates will consume not over one-half the time of the course, and that of mammals will become developed until it occupies almost one-fourth the total time. The major classes studied will be mammals, birds, and insects, and, as in botany, some classes will be entirely cut out of the course. There will be greater use of vivaria, indoor and outdoor; the latter, ponds and wooded tracts. In schools without definite courses in agriculture the zoology will incorporate certain phases of animal husbandry so that it will accredit such home projects as beekeeping, poultry keeping, the rearing of pigs and calves, and the spraying of orchard and garden for noxious insects.

While home projects will be many and the zoology course will be extended to include some phases of summer work, yet the classroom and the laboratory will be just as exact as now, if not more so, and a few good dissections will be demanded.

There will be definite work upon home and community sanitation under direction of, or in colaboration with, the local health bureau. There will be better knowledge of native mammals, the eradication of injurious and the conservation of beneficial forms. Here, too, there will be less of the book and more of the animal.

One of the greatest misfits in current education is sex hygiene; the physiologist would hand it to the physical director; the physical director hands it to the zoologist; the zoologist calls for a doctor; the botanist washes his hands of it entirely. We venture to say that tomorrow sex hygiene will not be taught as such, will not be treated as an individual problem, but that it will be approached from the angle of social hygiene, somewhat as follows. Nature conserves her races at least in part by elimination of the unfit; man reverses the act and conserves the idiots, imbeciles, lame, halt, and blind by assuming the burden of penitentiaries, asylums, and orphanages, and eliminates the fit by adding to their burdens, the unfit. The great current of inefficiency sweeps upon us in a constantly increasing stream of illegitimates whose real parents undertake no responsibility. Society will meet this problem face to face and wrestle with it biologically. The botanist will utilize his plant breeding, and the zoologist will use animal reproduction, to teach analogous human relationships. Seed selection presupposes parentage;

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stock breeding demands pedigree and type. Social sanitation calls for careful mating, and when the high schools of tomorrow teach that every boy and girl is a potential parent with a parent's responsibilities they will have done all that the most radical sex hygienist ever demanded. Thus biology will be more sociological, not too much, yet enough so that the pupils become good citizens.

If we may conclude anything from the present judgment of teachers in sixty-eight Illinois high schools who recently reported to the State Conference Committee, of which the writer was chairman, in the high school of tomorrow botany and zoology will be one-year courses, and physiology and physiography will be displaced by general science or its posthumous child. Botany and zoology will be given in alternate years.

Each subject will draw subject material from the other more freely than now, so becoming more bio-logical. The preliminary science, perhaps general science, will be more closely and more smoothly articulated with biology than now, and possibly the entire science course will be more unified so that there will be a definitely outlined series of subjects, each requiring a preceding one and each definitely contributing to a successor. Such a condition can come about only through closer supervision of the work and the appointment of a department head. A zoological principle must be followed—"specialization leads to cephalization."

Biology teachers are quite generally agreed that the weakest spot in their teaching today is in the manipulation of the laboratory. We forecast that the change in viewpoint and changes in material will alter our laboratory methods and solve this problem with which we are now wrestling. Less will be done for classes, but they will do more for themselves; the laboratory lesson will be partly prepared before appearance in class; the notebook will be less voluminous, the drawings limited to matter not to be discovered elsewhere than in the specimen, and the notes not to be formulated except by the pupil himself. Mere repetition of trivial observation or verification of common knowledge will be tabooed. The laboratory will be in part a museum and, in part, a workroom equipped with aquaria, vivaria, living birds and insects, growing plants and growing minds.

The biology of tomorrow will demand tomorrow's teachers. In biology more than in any other subject does the teaching

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depend up on the special training of the teacher; in other words, too often does the high school pupil receive instruction in only those things which the college or university decrees its students should get; soon these students begin to teach these topics to immature high school classes. They, in turn, fail to comprehend their work and grow to dislike it, until botany and zoology fail to attract many pupils or to contribute much to their development. In most of the larger cities, however, and in some smaller ones, biology teaching has been making long and rapid strides, so that now the pedagogy of high school botany and zoology has advanced quite beyond that of the university, and the university is now a drag upon the high schools. The failure of the colleges properly to instruct their outgoing graduates who have sought teacher's training is now the greatest obstacle in the advancement of high school biology.

This bitter arraignment of the university is running through the minds of hosts of high school teachers in many subjects. Repeatedly have they sent up cries for special training, the last having been at the Illinois Conference in Champaign, November 24, 1917. The Biology Section of the Central Association of Science and Mathematics Teachers in Des Moines four years ago resolved that the universities should do this thing, train prospective teachers in the content and aim of the high school course. As long as the college fails to hear this call, so long will the high school struggle on with its burden of poorly trained teachers and teachers out of sympathy with their environment.

The university further maintains its strangle hold upon high school biology through its domination of the textbook. Book publishers too long have followed the phantom that only college professors can write books. The texts in widest use today are those prepared by men actually in secondary teaching, or most nearly in touch with it. Our text will be written by high school teachers who will be ten or twenty years in advance of their time as to viewpoint, in the high school of tomororw, and the universities will no longer impose their neomonastic training upon us, but we shall both advance, abreast, both working for racial and social improvement and the conservation of those things which make life worth while.

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LABORATORY STORAGE AND FILING APPLIANCES.

By W. L. Eikenberry,
University of Kansas, Lawrence.

The safe and convenient storage of apparatus and supplies is always a problem. Some of the newer laboratories are generously provided with cases, drawers, storerooms, and special devices, but even here there is commonly a demand for additional space or for provision for storage of articles not taken into account by the architect. In the smaller schools and older buildings the problem is often one of the most serious that meets the teacher.

The efficiency of teaching is dependent upon proper storage of materials to a very considerable extent. If the teacher of a laboratory subject is to be free to give the proper amount of time and attention to the essential teaching problems, his time must not be monopolized by the routine work of getting out, setting up, and putting away apparatus. It should be possible for the teacher to put his hand upon any needed article at any time and without search. This means, of course, the storage of the numerous impedimenta of a laboratory in a large number of small units, preferably drawers, instead of tumbling them together miscellaneously in a few large drawers. It means that cork stoppers of the several sizes, rubber stoppers, rubber tubing, short pieces of glass tubing, tools, pinch cocks, pulleys, wire, screws, nails, staples, weights, clamps, burners, ad infinitum, should each have their separate and labeled location. It means that in a biological laboratory each sort of seed, twig, wood section, shells, soil samples, etc., must be readily at hand either for illustrative purposes or as a supply of materials for laboratory work. If the teacher can know absolutely that the materials for the laboratory study to be made by the class next day are in their proper places ready to be set before the class in the morning, hours of search and preparation may be saved in the preceding afternoon for recreation or for study. Such conditions can be achieved only with adequate provision for systematic storage of materials. No school board can afford to allow a teacher who is capable of teaching to spend his time on non-constructive routine that can be avoided by provision of proper facilities.

The essentials of a proper storage system are many. In the first place, it must provide for a great variety of objects. Shelves are suitable for bottles and for certain types of apparatus. Large drawers are useful for a few things, though they are much

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less useful than architects seem to think them. The small objects which ordinarily litter up tables, shelves, and drawers in cigar boxes, thread boxes, and paper bags, or lie around loose, always in the way excepting when they are wanted, can be stored satisfactorily only in drawers of size comparable to card catalog drawers. Maps and charts require either special cases or wide, shallow drawers.

A satisfactory system will be elastic in that it is possible to increase it as the laboratory grows and as the school can afford the investment. This is particularly important in the case of small schools, or schools in which only minimum provision for laboratory work was made when the building was constructed. Such elasticity not only allows the storage facilities to grow as rapidly as the need becomes apparent, but also allows these facilities to keep pace with the character of the demand as the courses grow or change.

Lastly, it is important for the purposes of most schools that the type of device adopted be one that is a commercial product rather than a special design, and therefore readily procurable at any time and at minimum cost. Special designs are always much more expensive than commercial goods, since the latter may be manufactured in quantity. Furthermore, special designs often cannot be secured when wanted.

Laboratory supply companies put out a good line of special laboratory furniture. Some articles, as the tables, can hardly be satisfactorily substituted by any commercial product, but the storage cases are commonly large and expensive, and do not afford much variety in the facilities offered. So far as the writer is aware, no laboratory supply company offers a case combining several sizes of small drawers, and thus suitable for general purposes in a small laboratory.

The obvious need has caused the writer to examine lines of commercial office equipment in the search for equipment adaptable to laboratory use. It has been found that much of the office furniture is well suited to laboratory purposes. Whenever so adaptable it offers the advantages of lower price due to quantity production, very considerable variety in the type of the devices, and the great elasticity due to sectional construction.

For the purposes of the Training School at the University of Kansas a horizontal unit, forty-two inches wide, has been adopted as the standard. For the storage of small objects we are using 18-drawer 3x5 card files and 12-drawer daily report

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files. The former contains in each section eighteen drawers with inside dimensions of 3½ x 5⅛ x 14½ inches. At our request the manufacturers made up the card drawers with solid bottoms and full height sides, but without rod and follower block used for cards. The charge for this change was nominal. The daily report drawers measure 3¼x8½x14 inches and are used as manufactured, no special work on them being necessary. The line of devices offered includes drawers of similar character, ranging from one and three-fourths to five inches deep, and up to eighteen inches wide, requiring no change to adapt them to laboratory storage purposes. Doubtless 4x6 and 5x8 card file drawers could be modified as were the 3x5 drawers if it were desired. The sections can be intermembered, of course, in any manner desired. In comparison with special cases of drawers offered as laboratory furniture and containing nearly a hundred small drawers, the saving in price appears to be about forty per cent. The greatest advantage lies in the fact that the sections secured fit our needs more exactly than would be true of any single type of drawer even though manufactured especially for laboratory use. Also, the fact that it was possible to start with a small investment allowed the immediate purchase of other needed laboratory furniture, which could not have been secured for a year or more if a large amount of money had been tied up in a single storage case.

For the storage of maps and charts there is available the type of office devices that are made for the storage of blue prints. Doubtless the best of these is a file that takes very large sheets in envelopes in vertical position after the manner of the vertical filing of correspondence. However, it is rather too expensive for most schools. A satisfactory device for medium sized maps may be secured in the form of a horizontal section uniform with those described above and offering drawers with inside dimensions of 2½ x 38 x 24½ inches, with four such drawers in a section.

The blue print drawers and the somewhat similar legal blank and insurance policy drawers of the deeper styles may be provided with cork bottoms and glass covers, and are then suitable for use as insect cabinets. This adaptation may be made in the school shops. Such use is now being made of them in the museum of the School of Education of the University of Chicago. All of these styles would also be readily usable for the storage of small specimens of rocks, minerals, lichens, wood sections, and other small class or display materials, and these can be provided

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with glass covers or not as the needs of the particular situation dictate.

It is scarcely necessary to call attention to the convenience of shelving the laboratory library in book sections in the same stacks, if desired.

Laboratory outlines, manuscript notes, blank paper supplies, and other miscellaneous materials of this character are best stored in vertical letter file drawers, three such drawers occupying a section. The use of tabbed folders will make it possible to keep together errant sheets of data on the same subject as a business house keeps together correspondence with one individual. Pictures mounted on ordinary 8x10 letter paper or on cards of that size are conveniently filed in the same manner. Of course for all of these purposes an abundance of guides, after the manner of guides in card catalogs, is necessary to facilitate quick reference.

The storage of pamphlets, such as the bulletins of the Department of Agriculture, is another matter that engages attention. Vertical filing is ideally adapted to caring for these publications. They may be stored on edge in letter file drawers much as cards are stored in card drawers. They will then be kept flat and preserved from dust and light, but at the same time be ready for instant consultation. They should be placed in such position that the back titles, if any are printed, will be readable, and that the title on the front cover can be seen by separating them slightly as one does with cards when consulting them. If the publications are grouped by subject in accordance with some system of classification, and a sufficient number of guides are used, no index to the bulletins is necessary. If classification numbers pertaining to the system used are placed upon both the guides and the pamphlets, it becomes very easy for a pupil assistant or other unskilled helper to return bulletins to their places in the file with accuracy. Catalogs and students' notebooks may also be cared for in the same manner.

While horizontal units containing vertical filing drawers as described above may be used for filing pamphlets, it is usually advisable, in the interest of economy, to use a slightly different style of unit. Vertical units, containing a larger number of drawers, are commonly supplied at a lower cost per drawer than horizontal units. Either the letter file or the invoice file may be used for pamphlets, though neither is exactly the right size for this service. A vertical letter file unit commonly contains four

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drawers with inside dimensions of 12⅛ inches wide and 10½ inches high. The width is satisfactory, but the height is somewhat greater than necessary, with consequent loss of space. An invoice file unit contains five drawers 8¼ inches high by 10 inches wide. This gives the advantage of five drawers instead of four, and the height is great enough for any material one is likely to have. However, the width is hardly satisfactory. Ten inches will contain Department of Agriculture bulletins, but it will not take separates from the *Journal of Agricultural Research* or *U. S. Fish Commission Bulletins*, for instance. The former are 7 x 10¼, and the latter 7¾ x 11. It has been found practicable to have the company manufacturing a line of filing devices, build a vertical unit in which drawers have the height of invoice drawers and the width of letter file drawers—that is, 8¼ x 12⅛ inches. This apparently occasions small difficulty in putting the order through the factory, as only nominal charge for the change was made. However, if it is not practicable to secure this special size, the letter file may be used with complete satisfaction; and the invoice file may be used within the limitations mentioned. A cheaper but fairly satisfactory outfit for the storage of pamphlets may be secured by the use of sectional transfer cases of letter file size. These are commonly used by business houses to store correspondence that is no longer in current use and which may therefore be stored in an out-of-the-way location. Since these files are not commonly consulted, the drawers are not built to be used with the same ease and convenience as the regular line of filing appliances, and they should not be purchased for pamphlet files unless under necessity, and then only after inspection has satisfied the purchaser that they will be perfectly satisfactory for his purposes. Their most serious fault is in the lack of any device to suspend the drawer when it is drawn out, and the absence of a follower to adjust to a varying bulk of contents.

It is well to call attention to the further fact that all types of office devices of the nature described are now made in steel as well as in wood. While the possibilities have not been investigated, it is supposed that little difficulty would be encountered in securing such slight modifications as have been suggested. The steel cabinets have the advantage of being more nearly vermin proof than the wood cabinets are. Damage by mice should be practically eliminated by use of steel storage, and that by insects could be greatly reduced.

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It is possible, therefore, to supply storage facilities for almost all laboratory property, with the exception of that preferably stored on shelves, by the use of commercial office devices. These devices need little or no modification from commercial standards to adapt them perfectly to laboratory uses. The elasticity of the system, as well as the excellence of the care it affords to laboratory property, is such that these devices are superior in general to the special furniture commonly sold for laboratory equipment.

AGRICULTURE OR BOTANY, WHICH?

By Vesta Holt,
Medford, Ore.

The tendency of recent years toward the practical has caused many to look askance at botany on the curricula of our high schools. Most of our progressive teachers have made the botany courses among the most practical, but our radical pedagogs have recalled the excessive nomenclature of the systematic botany of former days, and condemned botany as utterly useless. Others took up the cry and so, without trial, botany was in a fair way to be laid on the shelf alongside of astronomy.

Many schools substituted agriculture. Usually this was a slight modification of the eighth grade course, varying in value with the preparation and resourcefulness of the teacher. Such a course can hardly be popular. The students, as a rule, do not recall their previous work with a great deal of interest. Those who are vitally interested usually know nearly as much from their own experience and reading as is given in a high school course. We cannot give a college course for lack of time, equipment, and experimental farms. Also, for such a course, botanical principles are needed as a basis. Then, what are we going to do? Call our study agriculture and give our students practical botany? No, better yet call it by a new name and shape the course to fit local needs. We like to investigate new ground, especially if there is a connecting link with our previous experience—if there is a sufficient smack of familiarity to give us a little self-confidence.

Last spring we found in our high school three groups of students seeking a science elective. One group desired botany, the second wanted agriculture, while the third group were interested in neither. Our principal suggested agricultural botany as a solution. Those wanting botany were dubious, but willing

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to try it. The agriculture group were well pleased, while it sounded both practical and scientific to the third, and they were content.

As the teacher of the course, I was considerably puzzled as to what it should be. Furthermore, I had only one day in which to determine, as class work began the next day after registration. Two things were to be considered—the interests of the students in electing such a course, and the local field for work. The chief industry of the community was fruit raising, particularly pomes. Warren's *Elements of Agriculture* was chosen as a text, but not used during the first six weeks. This time was devoted to rather an intensive study of different forms of plant life, giving especial attention to physiology, growth, and environment. It was the intention to make the latter part of the course a study of the agriculture—particularly horticulture—of the community. Hence the aim of this beginning was to emphasize those principles that would be essential to that following. This made it possible to limit the broad field to the time allotted.

The remainder of the course included such subjects as seed germination, irrigation (a very vital topic in the Rogue River Valley at the time), drainage, soils, fertilization, plant pathology, grafting, plant breeding, etc. The county pathologist and entomologist took much interest in the course, and their assistance was invaluable. They gave practical demonstrations of diseases and insect pests of local importance, including excursions over the valley, where the effects and methods of combating them were shown.

Recognizing the varying interests of the class, we arranged for special work to be taken up by individual groups. This included a soil survey with samples, collection of weeds, Mendel's law charts, grafting including diagrams, charts, and photographs, etc. Four periods a week were devoted to laboratory work and part of this work was done at this time.

The course was a success from every point of view. We did not turn out expert orchardists, nor did we expect to. However we did succeed in giving to each one the basic principles to build upon if he desired. In this community there are none who do not feel the horticultural interest, hence its especially local value. The plan this year is to enlarge upon the course and make it a regular subject on the curriculum. It is no longer an experiment.

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THE MEASUREMENT OF HIGH SCHOOL MATHEMATICS.

By S. A. Courtis,

Supervisor of Educational Research, Detroit Public Schools.

When the Germans started to come through Belgium, the world expected the great forts along the border to hold out long enough to give the Allied forces a chance to rally to their defense. But the Germans had studied those fortresses; they knew the details of their construction and their strength. They had prepared themselves accordingly. Their big guns had been specially built for the express purpose of knocking the forts to pieces, and when the Germans were ready, concrete and steel crumbled to dust.

I have recalled to your mind this incident of the early history of the great war because I want to commend to your thoughtful consideration the subsequent behavior of the French. They, too, had forts along their borders, forts into whose construction they knew the utmost thought and care had gone. It would have been natural to feel that their forts were better, and that they could put up a better defense than the Belgians had done. However, they did nothing of the kind. They profited by the experience of the Belgians and changed their plans. By trench warfare they prevented the Germans from getting their big guns near enough to do at Verdun what they had previously done in Liege.

Some years ago war was declared in the educational world, war on the doctrine of formal discipline, and upon all subjects for whose presence in the curriculum formal discipline is given as a reason. The weapon of attack is the experiment and the educational test. The forty-two centimeter shell is the old theory of faculty psychology which the aggressors explode on all occasions with deadly effect. None of the old educational defenses can stand against it. At the present time, the enemy bids fair to carry all before them and to establish their "kultur" throughout the educational world.

When this war was first declared, the teachers of mathematics were all pacifists. The first attacks were directed against Greek and Latin, and many of you felt that you had no cause to intervene. You were more than half convinced by the enemy's arguments and thought that perhaps those dead languages deserved what they were getting. You withheld your assistance and the outposts have fallen. Greek has gone, Latin is going. Would you advise any young man to train himself to teach

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Greek in a secondary school today? I know a university professor of Latin, the head of the department in fact, a mature man with three children, who has seen the handwriting on the wall, and is today preparing himself for work in another field. There are many former teachers of Latin who are teaching Latin no longer.

Today it is high school mathematics that is under fire. When Dr. Snedden in 1914 raised the question as to why girls in high schools or men going to follow law, medicine, journalism, or theology, should study algebra, his conclusions were welcomed by a few, but scornfully rejected by most teachers of secondary mathematics. However, the reception accorded Dr. Flexner's *A Modern School* has been of quite a different character. Evidently the leaven has been working during the three years between the publication of these two documents. Some of you are waking up to the fact that this is your war, that it is your professional work that is endangered, and that far from being an academic question to be discussed pro and con in the spare moments of conventions, the problem of determining the validity of the doctrine of formal discipline is a vital, dynamic problem, upon whose solution one way or the other depends the outcome both of your professional career and of the teaching of mathematics in the secondary schools of the United States.

And so I come today to discuss this question with you from the viewpoint of a yardstick man. The invitation of your Secretary mentions "combating the influence of the ultracritical antagonists of mathematics," referring specifically to Dr. Flexner's *A Modern School*. I have accepted that invitation, although not perhaps in the sense in which it was extended, and I am here. But if you are really alive to the situation you will first of all demand that I show my colors and make clear with which side I am going to fight.

I class myself as primarily a formal disciplinarian, born and bred. If I cannot truthfully say I imbibed the doctrine in the milk from my mother's breast, because I wasn't raised that way, I am at least sure that it was securely planted in me by my father's shingle. With my father's able assistance I managed to pull through four years of Latin and two of Greek, but I believe my Latin teacher was retired on a pension shortly after, and my Greek teacher went to an early grave. I am sure that in these subjects I can qualify under the most rigid specifications. I had a full measure of discipline of one kind, only it

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was the wrong kind. I am frank to say, I could not see then, nor can I now, any beneficial disciplinary effects worth the time and effort expended, certainly none that could not have been obtained as well from more valuable and more interesting activities. Even such pleasure and culture as made themselves evident *came from reading the translations in the ponies* which my father found among his old schoolbooks in the garret. Never will I consciously aid in the subjection of adult, child, or beast, to training of that type.

In mathematics and science, however, the situation was entirely different. These were for me the profitable disciplines, and I have specialized in these two fields all my life. My seventeen years of teaching experience have all been gained in mathematics and science, and my present work is of the same general character. Now up to the time war on formal discipline was declared, I had always supposed I was transferring the general powers of observation, analysis, reasoning, etc., acquired by my study of science and mathematics, to all my work. I am of that opinion still although not so certain of it as I used to be. In other words, after mature and careful consideration of all the evidence presented by those who would have us think differently, I find nothing that has compelled me to surrender my early convictions. In spite of the courage it takes to say it, when I realize that I am running counter to the conclusions of such men as Dewey, Moore, and Spearman, I still believe that the study of mathematics may have a peculiar and distinctive function of a disciplinary character which would make it undesirable to substitute any other type of training for it.

On the other hand, even above my love for mathematics, I prize the truth. I rate myself a scientist and an experimentalist. In spite of my bias of personal prejudice in favor of formal discipline, I shall instantly abandon my position and strike my colors as soon as I find convincing evidence that is clearly against me. If, therefore, you are not equally willing to put your faith to the test, do not welcome me into your camp.

I have still another interest in this question, another viewpoint from which to judge. My oldest boy is in the seventh grade. In another year, or in two at most, I shall be compelled to take sides. That is, I shall probably be called upon to either wield a shingle as my father did before me, or to join the enemy by encouraging sedition and insurrection at home, if not by

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actually lending my support to the movement by other fathers and mothers to have mathematics eliminated from the high school course.

Therefore, I want to go over this matter with you carefully this morning, to define our problem as clearly as may be, and to discuss the steps that must be taken "to combat the influence of the ultracritical antagonists of mathematics."

The greatest difficulty that confronts us at the outset lies in the vagueness of our past thinking and writing. We have all seen so many instances of transfer in our own lives and in the lives of our pupils that we have been content to describe the phenomenon in the most general terms. "There, that is it," we say, pointing out a particular instance to our fellow teacher, and he, out of his common experience, understands what we mean. But these psychologists get us to commit ourselves to words and then pull our words to pieces because we were not careful to say precisely what we meant. It may even be that when we have succeeded in formulating a scientific statement of what we really mean by transfer, it will be acceptable to our critics also. One thing is certain; now they often talk about things we do not mean at all. For instance, Professor Dewey, in discussing transfer and formal discipline, says, "in the literal sense any transfer is miraculous and impossible." At another place he says, "Going to the root of the matter, the fundamental fallacy of the theory is its dualism; that is to say, its separation of activities and capacities from subject matter. There is no such thing as an ability to see, or hear, or remember in general; there is only the ability to see, or hear, or remember something. To talk about training a power, mental or physical, in general, apart from the subject matter involved in its exercise, is nonsense." Let us hasten to agree with Professor Dewey. We also believe that if a person sees, he sees something, that if he remembers, he must remember something. This should make it clear that if we speak of training the power of observation in general, we must do so in words which cannot by any possibility imply any supernatural power to observe when there is nothing to be observed.

Again, Professor Moore says[1]: "The universe of fact is no snug-fitting box with interchangeable parts which we can put together and take apart again. It is infinitely complex, and he

[1] *School & Society*, Vol. VI, No. 148.

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who is being trained to operate any part of it must be familiar with the characteristics of his particular field of fact and the process of manipulation which belongs to it."

Let us hasten to agree with Professor Moore, also. We do not even believe that learning Theorem I in a geometry text-book will automatically enable the student without further study to state Theorem II. Much less do we believe that the acquisition of skill in solving a problem in algebra will function as skill in playing a piano. We all recognize, I am sure, that in every act in life there are specific elements, and that each of these elements must be acquired by specific training. We do not expect the mechanic who has received only training to adjust a Packard engine to be able to adjust the engine of a Stanley steamer without additional training. We are even ready to admit that if a bank clerk had received such a long training in counting money of a certain kind in a small country bank that his counting had become well-nigh automatic, he would be almost certain to make mistakes when in a city bank he attempted to break up the old specific habits and substitute new ones for them.

None of these things are what we mean by transfer. They but serve to show how careless in our past statements we must have been, how careful we must be in the future. Clear definition of aims is not an easy thing to accomplish. We shall probably not succeed at any one time, and we shall want to modify our statements as our understanding grows. However, as long as we have faith that we are attempting to describe real phenomena, the mere fact that our analysis of the situation is faulty, our choice of words inadequate, does not prove that the thing itself does not exist. We must try and try again until we make our meaning clear. No failure should weaken our determination.

My understanding of the meaning of general training, the kind that transfers, is this. The activities of a new-born babe are determined by instinctive response to stimuli. As experiences multiply, however, other factors begin to operate. Feelings are aroused, reflection sets in, relations and meanings crystallize. The individual becomes conscious of his growth in power to profit by experience. He not only comes to have a larger and larger stock of specific knowledges and skills, but he comes to have also greater and greater power to select with precision from this stock of knowledges and skills just those of most use

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in a given situation, and he has greater assurance and skill in their manipulation.

It is probably this sense of conscious power to master the new situation in spite of any possibility of difficulties caused by the necessity to master the new specific elements in it, that has led to the term, "general power." General power consists of organized generalizations of past experience which roughly fit the new situation except for the adjustments made necessary by the new specific elements. It is not denied by anyone that observation, attention, memory, etc., are types of activities found in all situations into which consciousness enters. The theory of formal discipline assumes that, entirely aside from the specific character of certain elements of these activities, there are general methods of observing, remembering, etc., which it is advantageous to employ. The person who has conscious control over the general methods of efficiently carrying on any one of these types of activities has general power. I suggest that we define general training as that training which, while dealing with the acquisition of specific skills in a limited field, so directs the attention of the learner to the general details of the most efficient method by which success may be achieved that the individual being trained acquires not only specific skill, but a general philosophy of behavior applicable at once in all other situations of the same general type, upon the acquisition of any new specific skills that may be essential.

So far I have been speaking in general terms. Let me make the discussion more concrete. If a teacher of algebra uses the situations which arise to teach a student to classify and to generalize, if he brings to the consciousness of the student a knowledge of the laws and difficulties of generalization and gives him power to use the same in algebraic situations, the student will not only learn to factor well as soon as the specific elements of factoring are under control, but he will be able to transfer this power to, let us say, making a summary of a chapter in history just as soon as he masters the specific elements of such work.

Professor Moore has said: "Let the memory alone. Take no memory training lessons, give up forever the notion that a memory ever existed outside the world of fancy which could remember all things equally well, let memory alone, and give your whole attention to comprehending what you want to remember. That is all that you or anyone else can do. This

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you see requires us to shift our attention wholly from mind to the content."

This seems to me a faulty statement. In effect it says: "Pay no attention to the agent, concentrate your attention wholly on the content. Since your memory for theorems in geometry will differ from your memory for men in history, no benefit from the work you do in geometry can transfer to your work in history." This is probably absolutely true in the sense that no amount of training in remembering geometrical material is likely to affect your native memory for men in history, but it ignores that most important element, the person doing the remembering. He is a common element in both situations. If he learns in geometry the function that memory plays in successful work, he will see to it that he remembers in history, even if he had a good memory in geometry and a poor memory for names. This is exactly the importance of general training. The school cannot possibly hope to give training in *all* the specific skills which the individual must acquire. It must, however, teach the individual how to succeed in any situation that may arise, and if it so handles typical situations in school that the individual is graduated with a knowledge of the functions and laws of operation of the ten or twelve great fundamental activities of life, he may be counted on to take care of himself. In fact, so thoroughly convinced am I that general training is not only possible but absolutely essential, that I venture to prophesy that in the future the curriculum of the elementary school at least will be organized on the basis of activities and not of subject matter.[2]

I have recently seen an institute program on which Professor Whipple was scheduled to lecture on the fascinating subject, "How to Attend and Never Forget." Professor Whipple is, in my judgment, giving those three thousand teachers general memory training, because to be of value his recommendations must cover every type of specific memory there may be. As it will be quite impossible for him to mention them all, he must resort to generalizations and laws. We can be reasonably sure that in forty-five minutes not much of his lecture will take. The exposure is too short. But if Professor Whipple could give that same training to those same people in groups of thirty-five, using as a medium of transmission and experience

[2] I am indebted to Professor Thompson of the University of Colorado for the suggestions upon which this prophecy is based.

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a year's work in geometry, I am sure the transfer value of the course would be very great.

So far I have been following the bad example of our adversaries and making dogmatic statements of what I *believe* to be true, as if it were. Let me hasten to admit that I have no scientific evidence to support a single one of the many assertions I have made. Such evidence as I have, and I have plenty of it, is derived from personal experience and from observations of striking cases in the lives of others. Such evidence has no scientific validity and it is useless to present it. I am not discouraged, however, as my five years of effort to secure valid data have yielded returns which not only give promise that critical experimentation does not lie very far in the future, but also indicate points of weakness in the evidence of our opponents. We must be perfectly willing to abide by the results of valid tests, but under no circumstances should we accept returns at their face value; that is, without a careful study of their nature and reliability. No evidence can be accepted as valid until:

1. The criteria by which the nature of the abilities measured by the test were determined, are satisfactory.

2. The reliability of the tests used have been scientifically demonstrated.

3. Development of general ability in the specific field has been proved to exist before the test for transfer is made.

I wish to discuss each of these points.

Some years ago I constructed a test which I thought was a measure of ability to reason in arithmetic. Later I found that success in the test was dependent more upon reading ability than upon ability to reason. Would a study of the transfer of ability to reason from geometry to arithmetic, based upon the use of that test, lead to valid conclusions? Most certainly not. It was precisely such lack of transfer that led to the discovery of the real nature of the test. Now read through the various experiments that have been conducted to determine whether or not transfer takes place, and look for a discussion of the criteria by which it was determined that the tests used measured the abilities they were really supposed to measure. The science of test construction is in its infancy, and little has been done in the way of establishing criteria. Careful men like Professor Thorndike dodge the issue because no wholly satisfactory statement is possible at this time. For instance, Professor Thorndike says of his reading test, "Call achievement

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in paragraph reading that thing much of which enables an individual to respond correctly to a difficult paragraph and questions about a paragraph." This seems to me to be of the nature of educational camouflage. What he has done is to make a test in which the response on analysis proves to be influenced by such abilities among others as ability to read, reason, write, and spell. He is unable at this time to state what part each of these separate elements plays in determining the response, so he begs the question by saying, "I will call ability to do this complex thing reading ability." Reading ability *is* the chief factor in a successful completion of the test, but some children who fail in the test would be judged able to read by other standards.

The reason for our present uncertainty in regard to what tests measure lies in our lack of knowledge of the laws of combination of mental elements. If we put two pounds of sand into a one-pound box, the whole will weigh three pounds, at least within the limits of error of our apparatus. But if we add to any mental situation a single new factor, the result is not at all the sum of the component elements. For instance, all of you know how to walk, and walking is a complex and relatively stable habit. If now I were to dwell at length upon the need of grace in walking, and were to state that we had present in this audience a person renowned for his grace in walking, and if I were then to suddenly call upon *you* to walk across this platform that the audience might profit by your example, very many of you would suddenly become self-conscious. Your subsequent failure to walk naturally would really be a measure of your lack of control when self-conscious, not of your ability to walk.

I am sure you have all had the experience of setting what you thought was an easy examination, and of having your class "go all to pieces" on it. What happened was not the sudden evaporation of all the results of your teaching, but the transformation of what was apparently an examination in geometry into a situation which was really a test of self-control because of the introduction of some small factor judged to be of no importance. It is always extremely pertinent to inquire whether or not a given test really measures the ability it seems to measure before accepting conclusions based upon its use.

The need for a study of the reliability of a test is equally great. The reliability of a single trial of almost all our present mental and educational tests is low. Take my own arithmetic

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tests, for example. The general coefficient of reliability for the individual accuracy scores in addition was .5 for one group of children I measured. In division, the reliability was 0. This does not mean at all that the tests are valueless. The class score of a group of twenty children is a reliable measure of their general accuracy of work, but the scores of an individual indicate merely what he did in that test. In the next one his accuracy may vary from 100 per cent to 0, or vice versa, depending on the play of many factors. To determine the ability of an individual reliably, several tests under varying conditions are necessary before a safe inference is possible.

Now my addition test is a test of a very simple ability, relatively, and it was constructed after several years of experimental work. It is one of the most reliable tests of its type. Now, if the correlations between two trials of a geometry test is .4, and between two trials of a memory test is .5, and between the geometry and memory tests .2, how far is the apparent lack of correlation really caused by the unreliability of the tests themselves?

I wish there were time to discuss in detail with you some of the evidence that has been cited against transfer. I shall content myself with a single illustration, Dr. Rugg's careful experiment in measuring the transfer effect of a college course in descriptive geometry. You will remember that there were two groups. The control group did not take the course in geometry, the training group did. Both groups were measured at the beginning and at the end of the training period. Dr. Rugg summarizes part of the results in the statement:

"In attempts 67.8 per cent of the training group and 42.5 per cent of the control group gain in 60 per cent or more of the tests taken."

Professor Moore comments on this statement as follows:

"That is, 42½ folks out of every hundred who did not have the training took the tests as successfully as 68 out of every hundred who did have it. That is, the course seems to have been of some positive assistance in preparing only 25½ out of each hundred to take the test; to 32 out of every hundred who took it it was no help; and 42½ out of every hundred who took it got on just as well without it as with it, that is, so far as attempts went."

This raises some interesting questions. If 42½ folks out of every hundred who did not have the training took the tests as

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successfully as 68 out of every hundred who did, whence came this increased power? The changes in score may all have represented merely the unreliability of the tests themselves. On the other hand, these results might represent transfer from other courses. The students in the control group were not idle during the fifteen weeks. Yet one would hardly expect training in, say, English, to transfer to tests in the "mental manipulation of spatial elements." Perhaps the tests did not measure what they were supposed to measure. Dr. Rugg's statement on this point is over and over again: "Test 1 and 2 *are regarded* as giving measures of.....; Test 3 *is believed* to be a measure of .....; Tests 4 and 5 *are regarded* as measures of .....," etc., etc. But Dr. Rugg is careful to give the coefficients of correlation between these tests. For the initial trials of Tests 4 and 5, the correlation coefficients are .26 and .42, for the training and control groups respectively; for the final tests, .42 and .48. These figures speak for themselves.

Then again, the 32 individuals in the training group who made no gain, provoke all sort of desires for further information. Was their apparent lack of gain a result of merely chance variation, or was it due to the fact that they had nothing to transfer? Perhaps they spent fifteen weeks in work with Dr. Rugg and got nothing out of it as compared with the gains of the rest of the class. Now, Dr. Rugg is an excellent teacher, as I have reason to know, and if the University of Illinois furnished him with such poor material that in spite of his ability a third of the class were incapable of profiting by his efforts, was it fair to use these individuals as the subjects of a transfer experiment? I have always been told that it is essential to catch a hare before you try to skin it. It would seem wise, therefore, to make sure by appropriate tests that there was something to be transferred before attempting to measure the amount of the transfer. Perhaps some of the control group were morons also, or perhaps the other teachers were not as efficient as Dr. Rugg. At least it is clear that there were very many factors which might have determined the results. In the absence of exact knowledge one guess is as good as another.

I might review in similar fashion the thirty-odd other experiments dealing with the question of transfer and show that all of them are open to criticism on one point or another. I might select the work of Scholckow and Judd as the one significant experiment of the group. But I shall do none of these things.

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Instead I shall content myself with two quotations from Professor Thorndike. In his *Educational Psychology*[3] he says: "No one can doubt that *all* of the ordinary forms of home and school training have some influence upon mental traits in addition to the specific changes which they make in the particular function the improvement of which is their direct object. On the other hand, no careful observer would assert that the influence upon other mental traits is comparable in amount to that upon the direct object of training ..... The real question is not, 'Does improvement of one function alter others, but to what extent, and how, does it?' " Again he writes,[4] "A survey of experimental results is now needed perhaps as much to prevent the opposite superstition; for, apparently, some *careless thinkers* have rushed from the belief in totally general training to the belief that training is totally specialized."

The truth of the matter is that we are but just learning how to attack the problem experimentally and have not yet reached the point where conclusive results may be obtained. In our present experimental evidence there are plenty of suggestions which afford a basis for adopting the doctrine of formal discipline as a working hypothesis, provided we do not stop at this point and consider the adoption proof. Nevertheless, it seems to me perfectly evident that if the training in mathematics which we give is to have real transfer value it must be so organized and administered that it will produce transferable results. For nothing is more certain than that it is easily possible to *so* teach algebra and geometry that the teaching results in nothing more at best than specific skills. I, for one, am ready to agree with Professor David E. Smith that the presence of algebra and geometry in the curriculum cannot be justified wholly on the basis of their content or cultural values.

A point raised by Dr. Flexner and others needs discussion here. They suggest that equal general training may be given in connection with other work of higher content value. Some of us think differently. This difference of opinion should be settled on the basis of objective evidence. In my judgment, the distinctive function of mathematics in the curriculum is to make clear to immature minds the general method by which problems are solved, to teach them, as Professor Dewey says, "how knowledge arises." In terms of the formal discipline theory

[3] Vol. II, page 358.
[4] Vol. II, *Educational Psychology*, p. 364.

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their function is to give the student general training in the theory and practice of collecting, analyzing, classifying, and generalizing data, of formulating plans and executing them, and of evaluating the result achieved in terms of the result desired. To this end, algebra and geometry must be so taught as to afford opportunities for both inductive and deductive reasoning.

The reasons why similar training cannot be given as efficiently in other subjects are three:

1. In mathematics the subject matter is absolutely devoid of emotional appeal, so that attention is easily directed and held upon the essential elements of method.

2. The mathematical environment is the only one under man's absolute control, so that the difficulty of the problems presented may be perfectly adjusted from simple to complex to suit the progress of the learners. In mathematics alone is man an omnipotent creator. He speaks the word, and it is so. Parallel lines may be made to diverge, to meet at infinity, or to converge at will. Mathematics is the only "science of necessary conclusion," the only environment in which a man can check his reasoning processes against certain truth.

3. Mathematical apparatus is the cheapest on the market, requires less space, and affords a wider range of projects than any other. Paper, a ruler, a pencil, a compass, and a protractor give entrance to a universe full of concrete problems ranging in difficulty from the simplest to the most difficult yet conceived by the mind of man.

For the purpose of practical training in the development of general powers, we believe algebra and geometry are without equals. Who will produce the objective evidence with which to convince the world?

I have dwelt at length on this phase of the warfare, because I note a growing tendency on the part of mathematics teachers to be afraid to confess that they really believe in the doctrine of formal discipline. I hope to make it plain that as a working hypothesis it is still tenable, and to offset so far as I am able some of the recent articles that have been written. I think we have little to fear from such attacks, if both in our teaching and in our testing we prove that we are working consistently and efficiently, and are making progress. But there is another sort of attack that is much more dangerous because the charges made are easily proved.

For instance, Dr. Flexner says: "The education we are criti-

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cizing is overwhelmingly formal and traditional. Most children in the elementary and high schools struggle painfully and ineffectually to bring the subject matter of their studies within a world that is real and genuine for them. The best of them succeed fitfully. Most of them never succeed at all."

These are the real reasons why attacks on the presence of algebra and geometry in their present form are supported by public sentiment—*their formality and their failure.* The successful school may advance any theory it pleases to explain its success, but it must be successful, and its students must be convinced that they are succeeding during the period in which they are taught. Dr. Flexner voices this demand most clearly. If we piece together various sentences describing the basic principles upon which he thinks the curriculum of the modern school should be determined, we get this statement:

"A man educated in the modern sense will obtain his education form studies that serve real purposes. Its content, spirit, and aim will be realistic and genuine. The man will be trained to know, to care about, and to understand the world he lives in, both the physical world and the social world. A firm grasp of the physical world means the capacity to note and to interpret phenomena; a firm grasp of the social world means a comprehension of, and a sympathy with, current industry, current science, and current politics. The object in view would be to give the children the knowledge they need, and to develop in them the power to handle themselves in our own world. If a subject serves a purpose, it is eligible to the curriculum, otherwise not. The burden of proof woeuld be on the subject, not on those who stand ready to eliminate it. Modern education will include nothing simply because tradition recommends it or because its inutility has not been conclusively established. It proceeds in precisely the opposite way: *it includes nothing for which an affirmative case cannot now be made out.*"

I want you to note particularly that Dr. Flexner emphasizes the formality and failure of mathematics courses as taught at present. He refers to the doctrine of formal discipline more than once, but only to emphasize that it is "an unproved assumption" and, therefore, not a valid reason for including a subject in the curriculum. His real indictment of the formality of present mathematics teaching is as follows:

"The subject of mathematics offers peculiar difficulty. Perhaps nowhere else is waste through failure so great. More-

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over, even when a certain degree of success is attained, it happens often that it is quite unintelligent; children mechanically carry out certain operations in algebra, guided by arbitrary signs and models; or they learn memoriter a series of propositions in geometry. The hollowness of both performances—and most children do not accomplish even so much—is evident the moment a mathematical problem takes a slightly unfamiliar term. The child's helplessness exhibits a striking lack of both mechanical knowledge and 'mental discipline.' It cannot be that this training through failure is really valuable. Finally, a point might even be made on the ground that algebra and geometry as traditionally taught are mainly deductive exercises, whereas practical living involves the constant interplay of observation, induction, and deduction. The artificiality of conventional mathematics, therefore, raises a suspicion as to its value—even were the subjects mastered.

It is for those who believe in it to demonstrate how much good it does most children to make a failure in algebra and geometry. Is the elaborate study of mathematical and spatial relations through algebra and geometry a valid undertaking for its own sake? If so, neither the disinclination of the child nor the difficulty of the achievement is a reason for abandoning it. Disinclination and difficulty in that case simply put a problem up to the teachers of the subject; it is for them to find ways of triumphing over both. If, however, this study does not serve a legitimate and genuine purpose, then the mathematical curriculum must undergo a radical reorganization for the purpose of treating algebra and geometry from the standpoint of the other subjects which they serve. They would be taught in such form, in such amounts, and at such times as the other subjects required. Thus geometry would be decreased in amount by something like two-thirds or three-fourths,[5] and the form of the remaining fourth would be considerably modified."

His statement of the failure of mathematics teaching is equally strong: "It is perhaps worth while stopping long enough to show by figures the extent to which our current teaching fails. Complete statistics which would tell us how many of all the pupils who study algebra and geometry fail to master them do not exist. But we do know that a large percentage of the better students of these subjects try the college

[5] All the facts of geometry that a skilled mechanic or an engineer would ever need could be taught in a few lessons. All the rest is either obvious or is commercially and technically useless.—D. E. Smith, *Teaching of Geometry* (New York, 1911), p. 7.

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entrance examinations, and that for these examinations many receive special drill in addition to the regular teaching. Now in the examinations held by the College Entrance Board in 1915 ..... 69.7 per cent of those examined in algebra from quadratics on failed to make as much as 60 per cent; 42.4 per cent failed to make 60 per cent in plane geometry. What would the record be if all who studied these subjects were thus examined by an impartial, outside body? Probably some of those who fail do not do themselves justice; but as many—perhaps more—of the few who reach the really low mark of 60 per cent do so by means of devices that represent stultification rather than intelligence. For nothing is commoner in the teaching of ..... formal mathematics than drilling in arbitrary signs by means of which pupils determine mechanically what they should do without intelligent insight into what they are doing. It is therefore useless to inquire whether a knowledge of ..... mathematics is valuable, because pupils do not get it; and it is equally beside the mark to ask whether the effort to obtain this knowledge is a valuable discipline, since failure is so widespread that the only habits acquired through failing to learn ..... algebra are habits of slipshod work, of guessing, and of mechanical application of formulae, not themselves understood."

Are his statements valid? The judgment of the world is apparently that they are. If you don't believe it, you can easily test the matter for yourself. Compare your own percentages of failures and your own methods of teaching with those of some of the successful courses in a modern technical high school. This is not a question of formal discipline. There must be something to transfer before transfer can take place. This is a case of pedagogical inertia, paralysis, and stagnation We have persisted in the use of outworn methods and taken no account of the changing needs of the times.

I wonder what you will do about it? In this connection the article on the "Status of Mathematics in the Secondary School," signed by a committee of six mathematics teachers in and around Chicago, is very interesting reading.[6] They take seven pages of space to present the opinions of fifty-five adults as to the value of their mathematics training. In other words, in these days when men are realizing as never before that human judgment is unreliable and needs the check of objective measure-

[6] *School & Society*, Vol. VI, No. 151.

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ment, the best these mathematics teachers can do is to appeal to the opinions of men who went to school when the doctrine of formal discipline was as religiously accepted as was the doctrine of the literal inspiration of the Bible. It is interesting to note that of the fifty-five opinions, ten found the courses of practical worth, three others gave pleasure as the reason for its value. This, of course, leaves but forty-two to pass upon the transfer value. Of these, six, or 14 per cent, gave negative answers. The committee concludes: "These testimonies and the results of these investigations make it evident that algebra and geometry are not so much rubbish to be thrown out at the back door as quickly as possible, as some would have us think. The number who object to the requiring of mathematics in our high schools is relative a small minority, which in its effort to be heard sometimes makes a noise all out of proportion to its numbers. The professional, business, and industrial worlds, at least, demand for the present, and will demand for years to come, that algebra and geometry be retained as required studies in the secondary schools of our country; and this notwithstanding the efforts of educational theorists and would-be reformers to the contrary. Would it not be time and effort better spent if the destructionists were to aim at the perfecting of the subject matter, and the improvement of its teaching?"

Do you think that sort of a reply will have much weight with either the general public or the men who are devoting their lives to the improvement of education and to the formulation of an adequate educational philosophy? How much more reasonable is Dr. Flexner's statement, "Without considering any point settled, it is clear that a modern school which wiped the slate of mathematics and then subsequently wrote upon it only what was found to serve the real needs of quantitative thought and action, might evolve a curriculum in mathematics that we should not recognize."

Probably this is the place to comment on the way Dr. Flexner's *A Modern School* has been received. The newspaper reporters have interpreted it to the public as an attack on existing institutions. Certain schoolmen, also, have been greatly excited by these reports and seem unable to understand what Dr. Flexner has written. As I read his statements I find nothing but the desire to bring about exactly what the Committee of Mathematics Teachers demanded, the perfecting of the

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subject matter and the improvement of its teaching. Consider this paragraph, for instance:

"In education, as in other realms, the inquiring spirit will be the productive spirit. There is an important though not very extensive body of educational literature of philosophical and inspirational character; but there is little of scientific quality. The scientific spirit is just beginning to creep into elementary and secondary schools; and progress is slow, because the conditions are unfavorable. The modern school should be a laboratory from which would issue scientific studies of all kinds of educational problems—a laboratory, first of all, which would test and evaluate critically the fundamental propositions on which it is itself based, and the results as they are obtained."

In other words, a modern school that lives up to these ideals would not hesitate to try a course on any subject under heaven and by any method, provided a reason for such action could be advanced sufficiently plausible to make the trial worth while; provided, further, that the nature of the course and method gave promise that scientifically valid evidence would be secured as to whether or not the objectives of the course were being attained. For instance, both algebra and geometry are now actually being taught in the experimental school which has been established in New York City by the General Education Board. You know very well that if I say, as I want to say, that the only action for mathematics teachers to take is to face the situation squarely, criticize both subject matter and aims in the light of present needs and present knowledge, formulate anew the distinctive functions of the mathematical training, and then devise both methods that will produce the desired results and tests which will prove the fact, you will at once counter with the charge that you are not free; that you are bound both by convention and by college entrance requirements. This is precisely why the modern school should receive the enthusiastic support of all mathematics teachers who really believe in the value of training that they give. The modern school is to be bound by no traditions, is free from all requirements. "The education of the particular pupils who attend the modern school," says Dr. Flexner, "might prove to be the least of the services rendered by the school. More important would perhaps be its influence in setting up positive as against dogmatic educational standards."

This brings me to the real subject of my paper, to which

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all that has gone before is but the introduction. Positive educational standards can be set up in but one way, not by faith, not by hope, not even by the charity of biased or unbiased opinion, but by measurement, and by measurement alone, can educational goals be established. If the goals of mathematics training are to be transfer values, then tests for the measurement of such values must be devised, and your methods must be carefully studied and improved until they have been made as efficient as they can be. If the doctrine of formal discipline is wrong and the products of mathematics teaching are to be only certain specific knowledges and skills, then the amounts of such knowledges and skills to be developed must also be determined on the basis of exact measurement.

The program I recommend to you, therefore, has three main items.

1. Formulate as definitely and objectively as possible the aims of your teaching.

2. Study your method of teaching and make sure it is the one best adapted to bring about the desired results.

3. Devise standard tests which measure the product desired, and find out whether you are or are not securing these products as well as other teachers.

This is likely to take some time, and there is need for immediate action. If I were teaching a class in either algebra or geometry this year, I should give at the opening of the course, and repeat at its close, the Kansas Silent Reading Test and the Trabue Language Scale. Both of these tests measure roughly general ability. If possible, I should also test, in similar fashion, two other high school classes composed of pupils not taking mathematics. I could then compare the scores and growths made by my classes with those made by the other classes. The reason for the use of these particular tests is that they are easily given, can be scored by the students, and can be secured in duplicate forms of equal difficulty. I should use Form I of the Kansas Test for the first trial, making the time three minutes, and Form III for the second. I should use Scale B for the first trial of Trabue, and Scale C for the second.

If I were teaching algebra, I would give the Rugg Algebra Tests at the beginning and end of the semester and compare my results with those of other teachers. For geometry I would get in touch with some of the various committees on tests that are at work and give similar tests in geometry.

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For both algebra and geometry, I should also give the Thorndike Reading Test, Scale Alpha 2, at the beginning of the year. This would tell me which children could read and which could not, and I could then govern myself accordingly in helping my students. In similar fashion, if I were teaching algebra I would give at the beginning the Courtis Arithmetic Tests —for the fundamental operations, Test 7, Series A. This would tell me which children had command of the simple arithmetical skills and which did not, and I could adjust their work accordingly.

I should also compare the number of children dropping my subject and the number of failures I gave with similar data from other courses in the high school. All this would take a total of six or eight class periods and quite a number of hours of work outside of class, but when I got through I would have some real information about my work and I would know how to take the next step intelligently.

My friends, the enemy, which is no real enemy at all, but the best friend we have ever had, is at the gates. The outer defenses have fallen. Investigations are about to be made and, if necessary, changes. Are those investigations and those changes going to be made by persons now in charge of mathematics teaching and sympathetic with its highest aims, or by rank outsiders? The call to arms is sounding. The appeal is for your cooperation. What is to be your response?

NATURE STUDY SERIES.

An important contribution to the pedagogy of the field of science is just announced by the University of Chicago Press in a series of volumes to be known as *The University of Chicago Nature Study Series* and to be edited by Elliot R. Downing, Associate Professor of Natural Science in the School of Education at that institution. It has been a generation since an attempt was made to reorganize the methods of science teaching, and the books proposed are expected to be a distinct contribution to the development which is now in progress. The plan is to be inaugurated by a *Source Book in Biological Nature Study*, with a *Laboratory and Field Guide in Biological Nature Study*, and two notebooks—one for the elementary grades and another for the intermediate grades, all of which are being prepared by Professor Downing.

The purpose of the series is to fill the gap which now exists in the scientific education given by elementary and secondary schools. Science has long been taught in both types of school, but instruction has been of a haphazard character and is in need of reorganization. The School of Education of the University of Chicago, in the effort that it is making to improve grade and high school teaching in all departments, has found as a result of its investigations that the present methods of science teaching need a thorough overhauling in the interests of the child and of science itself.

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RECENT DEVELOPMENTS IN THE FIXATION OF ATMOSPHERIC NITROGEN.

By George W. Sears,
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The fixation of atmospheric nitrogen is rapidly becoming one of the world's most important industries. Professor Stieglitz, in his address before the Boston meeting of the American Chemical Society last fall, said, "The fixation of nitrogen plants in Germany has unquestionably saved her thus far both from a military collapse and from starvation." Nitrogen compounds not only form the basis of all explosives, but also are among the most important of plant foods. The importance of fixed nitrogen at the present time is therefore evident.

Until a comparatively few years ago, practically the only sources of fixed nitrogen were the deposits of Chile saltpeter and ammonia and ammonium compounds obtained from the destructive distillation of coal. Though the Chilean deposits are enormous they are not unlimited. At the normal increase in consumption it has been estimated that the supply would last approximately fifty years. Until the beginning of the present war the amount of ammonia obtained as a by-product in coal distillation was comparatively very small. It has been estimated that less than one-tenth of the bituminous coal in this country is coked in by-product ovens. In Germany all of the coke produced is made in plants fitted for the recovery of by-products, including ammonia.

The past two years in the United States have seen a very great increase both in the number of by-product coke ovens and in the amount of ammonia produced in this way. More than fifty million dollars' worth of by-product ovens have been erected during the past year, and the annual output of ammonia produced in this way has increased to about 115,000 tons. If there were a general use of coke instead of coal throughout the country the annual output of ammonia obtained as a by-product in its production would approximate 1,000,000 tons. The needs of the present war, however, could not wait for the carrying out of such a program. On the contrary, atmospheric nitrogen is being fixed by the old processes and by processes which differ from the old only in minor improvements, while new processes are rapidly being developed.

For the manufacture of explosives HNO_3 is demanded in large quantities, and as a fertilizer ammonia is of prime importance. At the opening of the war four general fixation methods

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were in use: The arc processes having HNO_3 as their immediate product, the Serpek process manufacturing AlN which is readily converted into ammonia, the cyanamide process manufacturing $CaCN_2$, which may be used as such or converted into ammonia, and the Haber process having ammonia as its immediate product. At the opening of the war this last process had just been placed upon a commercial basis, and up to the present time is used only in Germany.

Within the last year two other processes have been developed in the United States. One is a synthetic ammonia process devised by the General Chemical Company, for the carrying out of which they had begun a plant but stopped on account of the high cost of material. The process, however, was offered to the Government, and a plant is now being erected at Muscle Shoals, Va., for its use. The other process was devised by Professor Bucher of Brown University and is based on the manufacture of NaCN. The patent rights belong to the Nitrogen Products Company. It is not yet out of the experimental stage but, according to those who have investigated it, there is great probability that it will develop into the cheapest and most satisfactory process yet known. It was also offered to the Government and will be subject to further investigation by Government experts.

We are all more or less familiar with the arc processes, the principle of which depends on the direct union of oxygen and nitrogen to form nitric oxide under the influence of a powerful electric arc. The nitric oxide unites with more oxygen to form nitrogen peroxide, which is dissolved in water to form nitric acid or in alkali to form nitrates or nitrites. They possess the great advantages that the raw material, air, is free and always at hand, that only a small amount of labor is involved, and that nitric acid, the compound necessary in the manufacture of explosives, is the direct product. They depend, however, on cheap power, a thing which hardly exists outside of Norway, where water power is abundant. They also possess the disadvantage that the product HNO_3 is a very difficult substance to ship.

Nitrogen fixation by this process depends on the reversible reaction:

$$N_2 + O_2 \leftrightharpoons 2NO - 43{,}200 \text{ cal.}$$

Heat is therefore required to drive the reaction in the direction of the formation of NO. It has been found that at 2700° A.

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less than 2 per cent NO is formed. The speed of the reaction at this temperature is very high. Therefore, in order to obtain appreciable quantities of NO, the resulting gas mixture must be cooled as quickly as possible. Sufficiently high temperatures can be obtained in the electric arc. By its application, along with devices for very rapid cooling, it has been possible to obtain as high as 2 per cent of the air in the form of NO.

Among the later improvements perhaps the most notable is that of the Birkland-Eyde, the oldest of the arc furnaces. The ordinary furnace of this type consists of water-cooled copper electrodes, the points of which come close together. In this way an easily movable and flexible current is established. It is arranged in a highly magnetic field which draws the arc out perpendicular to the lines of force until the resistance becomes so great that it starts back at the points of the electrodes. Alternating current is used so that the arc has the appearance of a circular flame a few centimeters thick and about three meters in diameter. In the new arrangement the air is forced in across the flame instead of in the direction of the arc as formerly. A current of cooling air is directed into the furnace just above the arc. This has proved very effective in cooling the reaction product. The arc processes, though not feasible for installation in the United States because of the large quantity of power necessary, are of vast importance in Norway where cheap water power is available. So far nitrogen has been fixed more cheaply by the arc processes than by any other method.

Of the processes having for their object the production of ammonia, the Haber process has received by far the greatest recognition, and at the present time is undoubtedly the most important. It consists in the direct synthesis of ammonia from its elements. The reaction is as follows:

$$N_2+3H_2 \rightleftharpoons 2NH_3+23{,}780 \text{ cal.}$$

Since the reaction is exothermic any rise in temperature must decrease the concentration of ammonia at equilibrium, therefore the temperature must be kept as low as possible. On the other hand, the velocity of reaction will decrease with decreasing temperature. A catalytic agent, however, is used to increase the reaction velocity. According to the equation the volume decreases with the formation of ammonia so that an increase in pressure tends to drive the reaction toward the formation of ammonia. The process then consists in working in the presence of a catalytic agent at temperatures as low as possible

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and at pressures as high as possible. The temperature at which it is possible to work with sufficient speed depends entirely on the catalytic agent. A good many metals were found that would catalyze the reaction. Osmium, the most efficient, does not occur in sufficient quantities to make it practical. Uranium and tungsten were used in the early stages of the process. Finely divided iron is said to be used at the present time. The temperature of the reaction chamber is kept at 700° which is a very convenient temperature since steel may be used even with the high pressures necessary. The amount of ammonia formed under these conditions is probably not greater than four per cent of the mixture. It is necessary, therefore, to separate the ammonia and return the remaining nitrogen and hydrogen to the reaction chamber. The process in brief consists in working in a closed system composed of a reaction chamber in which the gas mixture comes in contact with the catalyzer at a temperature of about 700°, a cooling chamber in which the ammonia is liquefied and removed from the system, and pumps, drying agents, etc., to return the gases not acted upon to the reaction chamber and introduce fresh, dry gas. The whole system must be kept under pressures ranging from 125 to 150 atmospheres. That is one of the chief drawbacks of the process, though it is undoubtedly being operated successfully, for since the first plant was erected in 1913 by the Badische Company the output of ammonia has shown the very rapid increase from 20,000 tons $(NH_4)_2SO_4$ in that year to 300,000 tons in 1916, and it was estimated that during 1917 the output would reach 500,000 tons.

The success of the process depends in no small part on the purity of the nitrogen and hydrogen used. Comparatively pure nitrogen is obtained from liquid air. Hydrogen is made by the action of steam on hot coal or iron, and then purified before introducing into the system. The preparation and purification of hydrogen represents one of the chief items of cost in the process. The technical operation of the Haber process requires a corps of trained workmen who understand the details so necessary to its success. It is reported that if the Badische Company, who own and control the process, should lose its present technical staff of experts familiar with the process, it would be many months before another staff, capable of applying the process in practice, could be trained.

Concerning the synthetic ammonia process worked out by the

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General Chemical Company, very little information is at present available. It is claimed, however, that it does not require the high pressures necessary in the Haber process, and that ammonia can be produced by it considerably cheaper than by the Haber process.

The Bucher process for the production of NaCN, though still in the experimental stage, is so simple of operation, and the raw material is so cheap and easy to obtain, that it promises to give fixed nitrogen at a cost lower than that of any other known process. Dr. Parsons, chief chemist, Bureau of Mines, says of it, "From the chemist's standpoint the process is today a success. There is no difficulty whatever in the chemical reactions. When Na_2CO_3, ground coke or carbon in any form in contact with finely divided iron are heated to redness, and nitrogen or even air passed through the mass, nitrogen in quantity is fixed as NaCN. The reaction takes place readily. No power factor of any consequence is involved, and it appears certain that if the mechanical difficulties are solved, nitrogen will be fixed in this form cheaper than by any other known synthetic process. . . . The process has the further advantage that it would also make cheaply available cyanide, which is so greatly needed by our mining industries."

In discussing his process Professor Bucher says the idea is not new but that the fixation of atmospheric nitrogen to form alkali cyanides is by far the oldest of all such methods. In 1839 Lewis Thompson, while attempting to improve the method then in use for the manufacture of Prussian blue, found that KCN is formed when nitrogen is "allowed to act on a mixture of carbon and potash under favorable circumstances." In describing his method Thompson states that he found it necessary to use iron. "When iron is not employed," he says, "a much higher temperature is required." He ground together into a coarse powder two parts potash, two parts coke, and one part iron turnings, and heated the mixture in an open crucible in an open fire for about half an hour, and obtained an abundant yield of KCN.

The announcement of Thompson's results soon led to very active discussions and investigations by some of the most noted investigators of that time, including Berzelius and Bunsen. For some reason unexplained, however, all of these investigators omitted the iron from their mixture, and as a result were either not able to obtain cyanide or were able to obtain it only at very high temperatures.

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The early work of Professor Bucher on this subject consisted in the investigation of the following reactions:

$$2Na+2C+N_2 \rightarrow 2NaCN+46{,}200 \text{ cal.} \quad (1)$$

$$Na_2CO_3+2C \rightarrow 2Na+3CO-184{,}700 \text{ cal.} \quad (2)$$

Reaction (1) was found to proceed slowly, and the time required for completion was always a matter of hours. When iron was added to the mixture, however, the reaction was almost instantaneous at a low red heat. The catalytic effect of iron was therefore established. Its commercial application would depend on the possibility of obtaining cheap sodium. The applicability of reaction (2) was investigated for this purpose. A number of experiments combining the two reactions showed that cyanide could be prepared very readily at temperatures about 860° to 950° when iron was used as a catalyzer, but that appreciable quantities could not be obtained below 1000° in the absence of iron. This established the principle of the reaction. The next problem was to transform the laboratory experiment into a commercial possibility.

To get rid of the inconvenience of passing nitrogen over a powder, such as would be formed by the intimate mixture of Na_2CO_3, carbon and iron, briquettes were made. Of the methods tried out, that which gave most satisfactory results was as follows: The iron or hematite and carbon were ground separately until they would pass through a 100-mesh sieve. The two were then mixed and the grinding was continued for about an hour. The Na_2CO_3 was then added, and the mixture ground for about five minutes longer. The dry product was then placed in a steam jacketed mixer, and enough hot water added to make a thick paste. The briquettes were made by forcing this pasty mass through an ordinary meat grinder provided with a plate containing holes one-eighth inch in diameter. The knife was adjusted so that pieces about an inch long were cut off. These were dried in an oven. They formed a hard, dry briquette, quite free from dust.

It was found necessary to use hot water in the mixing in order to assure the formation of the monohydrated sodium carbonate since the formation of any of the decahydrate caused the briquettes to crumble on drying. The transition point from the deca- to the monohydrate is at 35°. A mixture of two parts iron, two parts coke, and one part soda was found to give the best results. It was also shown that air, producer gas, or even gas from combustion chambers could be used in place of nitrogen in the reaction.

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Both a batch and a continuous furnace had been tried out on an experimental scale and found to work quite satisfactorily. Certain mechanical difficulties, however, have prevented placing it immediately on a commercial scale. The chief object of the Government's investigation will be to solve those difficulties.

The extraction of the NaCN from the reaction product is accomplished in either of two ways, by distillation or by leaching. By the distillation process the cyanized briquettes are heated in a closed vessel to about 1000° and at 2 mm. pressure. The cyanide distills over and collects in a pool which solidifies to a clear glass. The method is claimed to effect an almost complete separation. It is necessary to observe certain precautions in the leaching process, owing to hydrolytic action on the NaCN, the formation of ferrocyanide, and the tendency of the dihydrate (NaCN, $2H_2O$) to "set" like plaster of Paris. To avoid these dilemmas the lixiviation temperature should be slightly above 35°, the transition temperature of the dihydrate, and the leaching carried out as quickly as possible. The solution when evaporated to dryness gives NaCN sufficiently pure for many purposes.

An idea of the cost of fixed nitrogen by this process may be had from the reactions involved. The reaction

$$Na_2CO_3+4C+N_2 \rightarrow 2NaCN+3CO-138{,}500 \text{ cal.}$$

would theoretically require 35,000 h. p. to produce 180,000 tons of HNO_3, allowing 85 per cent efficiency in oxidizing the ammonia. The three molecules would give on burning

$$3CO+1\tfrac{1}{2}O_2 \rightarrow 3CO_2+200{,}000 \text{ cal.}$$

equivalent to about 50,000 h. p. to help make up the unavoidable heat losses. Combining the two reactions it is seen that the total reaction is exothermic, showing at least that the power factor is of little consequence. The great simplicity of the process and the low cost of the materials used also indicate that the method should produce fixed nitrogen at a very low cost as compared to other processes now in use.

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THE SOLAR ECLIPSE OE JUNE 8

By William B. Thomas,
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Since eclipses recur in a cycle of eighteen years, eleven and one-third days, nearly, the solar eclipse of June 8 is regarded as a repetition of that of May 28, 1900. Since, however, this eighteen-year period, the Saros of the Chaldeans, is not an exact dividend of the days in the year combined with the moon's motion, each succeeding appearance of the corresponding eclipse comes some eleven days later in the year; but since the earth has completed .32 of a new rotation, in other words has spun off a third of an additional day before the conditions making the eclipse arrive, at the end of the Saros, each recurrence is seen some 120° of longitude farther west than the one preceding. When it is added that every third Saros brings a specific eclipse approximately to the same longitude, it will be seen that anyone who will apply the sense of the facts just given, as far as they go, is predicting an eclipse, in a rough way.

The general conditions of the event being now given, the eclipse of June 8 may be examined. If the rotational motion of the earth were to cease for the afternoon of that date, at about 3:35, counted as Chicago time (or 4:35 counted as "daylight-saving-time" at Chicago), from a very high aeroplane, properly situated, a shadow, moving from thirty to forty miles a minute in the general direction, southeast, might be seen starting to flit over the continent. It would enter off Washington and leave the continent off Florida. We are supposing the earth to stop, but the usual phenomena of time and daylight to go on. This could not be, and, in reality, the minute of arrival, anywhere, of this unusual shadow is complicated by factors, such as the latitude of the observer, his nearness to the exact center of totality, and, of course, the rotational motion of the earth. The shadow moves forward like that of a cloud seen over a hilly countryside, but in a manner calculable mathematically.

The general data of eclipses are well enough known. For example, Oppolzer's lists trace all eclipses occurring for over eight centuries. The following years will bring total eclipses visible in the United States, namely: 1918, 1923, 1925, 1945, 1954, 1979, 1984, and 1994. Obviously, all these are not that of 1918 repeated. The same definite locality will not observe a total eclipse oftener than once in 360 years. The Naval Observatory publishes in the *Nautical Almanac* exact circumstances

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of eclipses each year. Owing to the line of totality, full calculations, this year, are given for Denver, Col., with local circumstances for seventy-seven other points. These circumstances, as they are called, are concerned with the time, magnitude, and angle of the shadow at the beginning, middle, and end. The region of totality must be considered favorable this year. The eclipse may be observed at places easily accessible, and the uncalculable meteorological factor stands a good chance of being auspicious. The corresponding eclipse of 1900 appearing about 8 o'clock in the morning, in the Rocky Mountain district, was seen as a partial eclipse in a perfectly clear sky. The various matters of addition to theoretical knowledge which await the coming of a total eclipse render it sure that even war conditions will not prevent a careful scrutiny of this phenomenon, the present June, and the leaving of records for the future. Quite obviously, since science is progressive, equipment for study was never before quite so perfect for the making of an observation. The minute or two of totality shown in the *Almanac* on page 561 as occurring on the central line will be a time of close watching and careful comparison.

The area of totality for a total solar eclipse being narrow and variable, each observer who cares to do so may calculate for himself such items as (1) *position of point of contact*, (2) *time of maximum eclipse, and* (3) *magnitude of maximum eclipse.* A glance about page 729 of the *Almanac* will show the laboriousness of this work. It will readily appear that it is done largely by division of labor and the sharing of results. The reader, however, cannot inform himself of the processes employed better than by a following of the descriptions given in standard texts on the subject, and especially in the *Nautical Almanac.* What are known as the Besselian elements are used; in other words, the problem is stated geometrically, these elements of the problem are supplied by the *Almanac*, and calculations are then made. The formulas employed, respectively, for the items enumerated above will illustrate the method, though they will not be fully intelligible without reference to page 728 of the *Almanac.* They are:

$$P = N + \psi \qquad (1)$$

$$\tau = \frac{m \cos(M+N)}{n} \qquad (2)$$

$$D = \frac{L - \Delta}{2L - 0.5446} \qquad (3)$$

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THE DOCTRINE OF FORMAL DISCIPLINE.

By Nathan A. Harvey,

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I have been much interested in the attempted defense of the doctrine of formal discipline by Professor Young in the January and February numbers of School Science. I refer to the articles upon "Transfer of Training," and the "Disciplinary Value of Studies."

Professor Young objects to the statement of the doctrine in the writings of many opponents of it, saying that "Even opponents seldom set up a careful definition of the doctrine, and when a definition is set up, it is done with the avowed purpose of knocking the doctrine down" (p. 132). Then Professor Young asks, "Was there ever anyone who seriously held this prostrate doctrine?" Also, Professor Young seriously objects to Heck's statement, with its implications and its illustration of the release of water through different pipes from a common reservoir. In a comment upon Bagley's statement of it, he reiterates the question, "Who ever held such views?"

I am inclined to believe that Heck's statement is fairly representative of the doctrine, although I would prefer to use my own statement. It is exceedingly dangerous for a man to quote from his own writings, but I am going to venture to do so in this case. In a book, *Principles of Teaching*, which I sincerely hope Professor Young will never see, I have used such expressions as these: "Some persons have undertaken to establish mental discipline as the true purpose (of education). It is believed that the real purpose of education is not the accumulation of knowledge but the training of the mind. The mind, through its processes of learning, becomes able to do what otherwise would be impossible for it" (p. 70). "They affirm that it is not the knowledge of the subject which is the matter of special importance, but that in the study by which the knowledge of the subject is gained, power and ability to do mental work in any direction is acquired" (p. 71). "The psychological theory, under the influence of which this idea of mental discipline has been developed, assumes that the mind has certain powers which need to be cultivated" (p. 71). "It assumes (the theory of mental discipline), as a fundamental postulate, that power gained in the study of one subject is capable of being applied to the study of any other subject" (p. 73).

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If this is a man of straw, I should like to exhibit some of the straw of which the man is made.

1. All studies give useful information, and all studies can be so pursued as to aid in the development of mental power. And however valuable the knowledge gained, the growth of power should be the chief aim of all our school work.[1]

2. Any power under the control of the will may be cultivated, or trained.[2]

3. The powers are trained in one way, and in one way only; viz., by wise use.[3]

4. Any power of the mind grows strong by the activity of that power against appropriate resistance.[4]

5. The several powers are developed by occasioning the natural activity of each. Exercise strengthens faculty.[5]

6. In the primary school period, perception is trained by handling and observing objects; memory incidentally by all the work of the grade, and in special ways by memorizing gems of literature; imagination by tales and descriptions, and such designs and constructions as are employed in the kindergarten; the thinking faculty by use of simple judgment and reasons; proper emotion is fostered in many ways adapted to the dispositions and needs of the child; the will is strengthened by the restraints and demands of the school room.[6]

7. (During the high school period.).....The Inductive reason is trained by inductions in science and history, the deductive reason by mathematics, the finer emotions are developed in the study of literature.[7]

8. Now mental activity is, strictly speaking, one and indivisible. The mind is not a complex substance, composed of parts, but single and one.[8]

9. .....The simple truth (with large implications) is that each soul is one thing, a unity, an essence, spiritual in its nature, and thereby absolutely indivisible.[9]

10. Remaining always a one thing, this one thing is developed

[1]Hewett, *Pedagogy*, p. 41. Dr. Hewett was President of the Illinois State Normal University, an influential teacher, whose teachings are still exercising a marked influence upon educational practices, and who reflected in a very complete way, the psychological opinions of his time.

[2]Hewett, *Pedagogy*, p. 45.

[3]Hewett, *Pedagogy*, p. 45.

[4]Salisbury, *Theory of Teaching*, p. 241. Mr. Salisbury was President of the State Normal School at Whitewater, Wis., a very influential teacher, whose book is still widely used, and who represented in rather a satisfactory manner, the psychological opinion of his day.

[5]Salisbury, *Theory of Teaching*, p. 245.

[6]Baker, *Elementary Psychology*, p. 163. Mr. Baker was President of the University of Colorado, a Past President of the National Education Association, member of the Committee of Ten, and knew the psychological and educational theories of his day.

[7]Baker, *Elementary Psychology*, p. 164.

[8]Haven, *Mental Philosophy*, p. 29. This was a very representative and popular textbook on psychology.

[9]Jones, *Education as Growth*, p. 23. President Jones was Superintendent of Schools in Indianapolis, Cleveland, and President of the Michigan State Normal College. He represented well a very large body of educational theory and practice.

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and made greater and more worthy or powerful, through the proper exercise of these capacities; and the process by which such increase of power, or worthiness, is gained, is properly called education, whether attained in school, or in other disciplines of life.[10]

11. I believe that four years of high school Latin is best for the ordinary high school boy or girl, because of the mental training involved.[11]

12. May I repeat.....a student properly trained in the Greek and Latin languages, and in mathematics,.....comes to the university equipped to attack successfully whatever is offered him.[12]

I have selected the above extracts from the first half-dozen books picked up from my table. I believe that a very brief search through the library would enable me to multiply the number of similar quotations by a hundred. It seems to me that there is abundant material in these few quotations to justify every phrase in the statement of the doctrine of formal discipline outlined above. It appears also, that there is in these few quotations a sufficient answer to Professor Young's rather contemptuous inquiry, "Who ever believed that?"

The doctrine of formal discipline is still influential. It is believed in by many persons. It is, however, inconsistent with the Herbartian doctrine of apperception, and anyone who adheres to the apperception doctrine cannot adhere to the doctrine of formal discipline. It is also inconsistent with the doctrine of localization of function, and if the doctrine of localization of function has been established, the doctrine of formal discipline has been disproved.

The doctrine of formal discipline assumes that the mind is a thing, with certain powers that can be strengthened by exercise. Modern psychology knows nothing of this power-possessing thing, and consequently the doctrine of formal discipline falls with the assumption which is necessary to it.

I believe that there is sufficient evidence from experimental studies to justify our belief that the doctrine of formal discipline has been disproved by experiment. The results are not so convincingly complete as to amount to demonstration, nor sufficiently strong to convince a person who is unwilling to give up the doctrine, that he must do so. Certainly, however, the result of experiment lends no comfort to the advocates of the doctrine, and all psychological tendencies are against it.

[10]Jones, *Education as Growth*, p. 23.
[11]Francis Ramalay, *University of Colorado Bulletin*, 1914, Vol. XIV., No. 9, p. 33.
[12]John B. Ekeley, *University of Colorado Bulletin*, 1914, Vol. XIV, No. 9, p. 18.

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SOME PHASES OF SPRING NATURE STUDY.

By C. F. Curtis Riley,
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The spring is always an interesting period for the study of outdoor life. At this time of the year many animals and plants are arousing from the lethargy of winter. Therefore, the spring brings with it ample opportunities for nature study work. While the summer may be considered to be the more ideal season for out-of-door study, yet the spring is the most favorable time for certain kinds of nature study observations. In fact, some phases of such work can be undertaken only at this time of the year.

Bird study is a profitable phase of nature study, in the spring. The identification of the spring birds offers many interesting and unusual experiences. The color, form, and size of a bird are useful factors in the process of identification. The song of a bird is frequently helpful in naming the species, even when the creature itself is not visible. Some peculiarity of flight is often the only factor necessary to identify the bird. When a bird is on the ground, or in a tree, certain characteristic movements of the tail, head, or wings are sufficient to materially assist the observer in recognizing the species. There are many books on birds, but they are not all of equal value for purposes of bird identification. The following books are recommended as being reliable for this purpose: *Handbook of Birds of Eastern North America*, by F. M. Chapman; *Color Key to North American Birds*, by F. M. Chapman; *Bird Life*, by F. M. Chapman; *Wild Birds in City Parks*, by H. E. and A. H. Walter; *Birds of New York*, Part 1; Part 2, by E. H. Eaton; *Bird Guide*, Part 1, "Land Birds"; Part 2, "Water Birds," by C. A. Reed; *How to Know the Wild Birds of Illinois*, by D. Lange; *A Guide to the Birds of New England and Eastern New York*, by R. Hoffmann; *Birds of the Western United States*, by F. M. Bailey; and *Birds Through an Opera Glass*, by F. A. Merriam. Many other books, besides those that have just been enumerated, treat upon the subject of the identification of birds, but it is believed that any one of these will prove to be very useful in assisting the beginner to become acquainted with a large number of the common species.

Besides identification, there are other phases of bird study that are fully as interesting and equally valuable. The spring provides an excellent opportunity for work of such character.

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The return of the birds always creates an interest in some of their more obvious forms of behavior, among groups of people of varying interests. At this season of the year many species of birds are actively migrating. For some time, different species may appear each day. In connection with the study of bird migration, the preparation of a bird calendar provides an interesting method of recording valuable data. The following are the more important facts to be recorded: the name of the bird, the date on which it was observed, the location of the bird, the name of the person who made the observation, and finally any general remarks concerning the bird. Under the last heading, such questions as these may be answered: was the bird feeding, and what was the nature of the food; was the bird building a nest; was the bird observed in some unusual position; was it on the ground, or in a tree, etc.? It will prove very interesting to notice the variety and number of species that are recorded in so short a period as two weeks. A valuable comparison can be made between the variety and number of species recorded during the first week of observation and the variety and number of species of the last week of observation. After the bird calendar observations have been recorded for a month or more, a summary should be made. When this is done, special attention should be focused upon the preponderance of certain species of birds and the scarcity of others. The weather conditions and the abundance or the sparseness of food should be noted, carefully.

Many species of birds are relatively tame during the early spring. The instinct of fear appears to be subordinated at this time, while the food, nesting, and migration instincts predominate. The subordination of the instinct of fear is very noticeable during the breeding period. Advantage should be taken of these facts in order to study the bird habits that predominate at this season of the year. In connection with food habits, particular attention should be directed to the kind of food sought by the birds and also to the behavior of the birds in obtaining such food. Observations of this character, if carefully made, may be of permanent value, especially to the gardener and the farmer. Many of the spring birds are found to be seed eaters; some are observed to seek insects as food; others eat the buds and early fruits; and still others prove to be mixed feeders.

There are few of the spring habits of birds more fascinating

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to the observer than that of nest building. It is well worth the time necessary for observation to notice the different kinds of materials used by different species of birds during this process. In general, it may be stated that song birds use grass, hair, small twigs, and fine fibrous roots in building their nests. Some species of these birds plaster such materials together with clay and mud. The coarser materials are placed at the bottom, or foundation, and on the outside of the nest. The finer materials are worked into the upper and inner parts of the nest. Frequently the nests of these birds are lined with feathers. It may be worth while to recall, specifically, the materials used in nest building by several different species of birds. The house wren builds its nest of sticks and twigs, and lines it with grass, feathers, and cottonwood down. The Baltimore oriole uses building materials of hair, string, grasses, and bark fibers. These are formed into a sort of network, and are woven together, the process displaying much skill on the part of the bird. The result is a little swinging sack, placed at the end of a branch, high in a tree. The nest of the ruby-throated humming bird is built very compactly, and it is very small in size. It consists mainly of moss and plant fibers, covered externally with lichens, and lined with cotton. It is also of interest to observe where the birds obtain the building materials. Much of this is found in the immediate vicinity where the nest is to be located, but some of it may be brought from considerable distances. For example, a Baltimore oriole was watched as it picked up in its bill pieces of string and carried them away to be woven into its nest. The string had been thrown onto a refuse pile directly under the soft maple tree in which the bird had built its nest. Another example was that of a robin which was observed to carry mud, for nest building, for a distance of a quarter of a mile.

Certain species of birds are much more difficult to observe than others. This applies not only to nest building habits, but also to other habits as well. Therefore, it is decidedly worth while to make a careful selection. The following common birds have been found to be suitable for the study of habits: the robin, the meadow lark, the catbird, the house wren, the Baltimore oriole, the house sparrow, the blue jay, the brown thrasher, and the black-billed cuckoo.[1] The study of bird

[1]Herrick, F. H., "Life and Behavior of the Cuckoo," *Jour. Exper. Zool.*, Vol. 9, pp 169–233, 1910.

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habits and general bird behavior is becoming more and more a most important feature of general bird study In fact, many valuable and interesting facts have accrued to genetic animal psychology through observations of this character.

Another valuable form of nature study work, at this season of the year, is the observation and study of the early spring flowers. There is a certain degree of satisfaction, in fact a fascination, in discovering the first violet or the first anemone. It is also an interesting experience to find flowers in unusual locations. I had frequently heard of violets growing in close proximity to snow banks, but not until I found them in such a location, near Duluth, Minnesota, did such a statement have any real meaning for me. Favorable spots to look for spring flowers are sunny banks, open timber, and protected hillsides. Some of the best of these early spring flowers should be collected, carefully pressed and dried, for the purpose of forming a herbarium. The making of a spring flower calendar is just as interesting and just as valuable as the making of a spring bird calendar. The date of the observation of the flower, the kind of flower, the location of the flower, and the approximate number of individual flowers of different species in a specific location, are all facts worthy of record.

The study of trees in their early and late spring conditions presents many profitable lessons in nature study. Their grouping and classification is an interesting phase of study. The form of the tree, the character of the bark, the method of branching, and the type of buds should all be considered in work of this nature. Such trees as the pines, elms, maples, birches, oaks, butternuts, basswoods, ashes, and hickories are especially suitable for this sort of observational study. The appearance of areas of color in our forests, during the early spring, is an interesting phenomenon. The outer layer of tissue is thin and somewhat translucent on the young twigs of certain species of trees, and as the spring progresses, this region displays touches of color. This is evident on the young stems that still retain the epidermis, the thin external layer, and on which the periderm, a form of secondary growth that supplants the spidermis, has not yet developed, or at least has not fully developed. The presence of this color is a result of the renewed chemical and physiological activity, which occurs in the spring of the year. It is due to such changes as these that the coloring becomes evident in our northern woods before the buds have opened,

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thus producing an aesthetic effect in the leafless forests. Attention should be directed to the various types of buds, and to their manner of unfolding. It should not be forgotten that trees belong to the true flowering plants. While these flowers are not nearly so showy as the flowers of our gardens, they are none the less true flowers, possessing all the possibilities of such structures.

The brook, as an insect habitat in the spring, will well repay even the most casual observer. The whirligig beetles that spin in dizzy circles on its glossy surface are a never-ending source of wonder. One speculates in amazement upon the evolution of such an astonishingly peculiar form of behavior. On picking one of them from the surface of the water, its body is found to be hard in texture and of a blue-black color. It possesses wings and three pairs of legs. While these insects fly with ease, they apparently do not fly directly from the surface of the water, but first must climb up the stem of some aquatic plant. The eyes are separated into two parts, and it has been inferred that one serves for vision in the air and the other for vision in the water.

One finds also that several species of diving beetles are inhabitants of the brook. It is very interesting to watch one of these insects suddenly come up to the surface for air, and then, just as suddenly, dive down again to the bottom of the stream. Some of these beetles and their larvae are decidedly predacious. This is especially true of that group, or genus, of beetles known as the *Dytiscus*. The larvae feed on other insects, worms, snails, and tadpoles. Some writers state that small fishes also become their prey. It is interesting to notice that the structure of the body of diving beetles is well adapted to an aquatic existence. The legs are broad and flat, and they are functional in swimming, being used much in the same manner as are the oars of a boat. The surface of the body is smooth, thus the friction of the water is reduced. The boat-like configuration of the body suggests adaptation to the mode of life of the insect. An interesting fact to the nature study student is that these beetles and their larvae thrive well in aquaria. The observer then notices that such creatures lead a very active life. In confinement, their various forms of behavior, such as swimming, diving, breathing, capturing prey, and feeding are observed readily.

Several species of water striders are found to be skating gracefully over the surface of the stream. The bodies of these

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insects do not touch the water. The legs are very long and slender and are stretched widely apart. These structures support the body and raise it above the surface of the stream. These interesting creatures do not break through the surface film of the water, but they are supported by it, and glide about on its surface. The striders constantly face the current, upstream. This is a form of response which probably is adaptive, as it provides them with food, in the form of insects, which floats downstream.

In the shallower water of the brook, where it forms small ripples as the current flows over the rocks, stones, and gravelly bottom, frequently are found the larvae of the caddice fly. In such a location, food can be carried to the larvae by means of the current. These creatures are observed to be some distance below the surface of the water, attached to rocks, stones, aquatic plants, and the gravelly bed of the stream. Some kinds of caddice fly larvae are more or less active in obtaining food. If a number of the larvae are examined, it is noticed that the cases, or sheaths, which vary very much in shape, entirely surround their bodies. Careful observation discloses that some of the cases, containing larvae, are not attached to any solid object, and although the sheaths, frequently, are constructed of heavy materials, they are carried about easily, because of the buoyancy of the water. In general, the cases are cylindrical in outline. However, they may be flattened, irregular, rough with sharp projections, smooth, or symmetrical in configuration. The body of each larva is surrounded by a tube, made from a silky material which is produced by the animal itself. This silk-like cylinder forms a lining within the sheath, which forms the outer wall around the body of the larva. The cases of the caddice fly larvae are built out of various different materials, such as portions of leaves, particles of gravel and stone, and small pieces of wood. Sheaths have been found that were formed from fragments of aquatic plants, the genus *Equisetum* for example. Some are so constructed that they exhibit a fine symmetry, while others are totally lacking in this quality. The various parts of which the cases are composed are fastened together by means of the silk-like material which is spun by the larvae. This substance is somewhat viscid, which property is of decided value in holding together the individual parts of the sheath.

The larvae of the caddice fly are often spoken of as caddice

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worms. They are worm-like, or caterpillar-like, in general appearance. From this stage of development, they are transformed into pupae. Frequently, during the larval stage, the two ends of the case may be open. Through the front opening, the larva protrudes its head. After the larva begins to metamorphose and before it passes into the pupal stage, these openings are closed by the creature itself. The two ends of the case may be closed by means of the mucilaginous, silk-like material that has been mentioned previously, or these apertures may be closed by the use of some other substance. I have found pupae in brooks during the months of May and June in such diverse localities as Duluth, Minnesota; Milwaukee, Wisconsin; Urbana, Illinois; and Covington, Indiana. Occasionally, I have observed them earlier than this. Such examples may have passed the winter in this condition. Sometimes the pupal cases are found to be considerably shorter than those in which the larvae are enclosed. When the pupa is ready to transform into the mature caddice fly, it crawls up the stem of some aquatic plant, or other support, which extends above the surface of the water. After reaching the open air, the mature caddice fly emerges. Soon the wings expand, become dry, and the insect flies away. Some species of this insect transform beneath the surface of the water. The mature insects are superficially similar to the group to which the butterflies and moths belong. They are dull-colored creatures, frequently brownish. They have four wings, which are veined. The feelers are long and slender. They are not very strong fliers, but they make short flights in the vicinity of the stream from which they have emerged.

There are many other interesting forms of life in the brook. Besides those creatures that already have been described, there are water boatmen, back swimmers, water scorpions, May fly nymphs, and many other curious types of insect life, all of which possess their own interesting and individual forms of behavior. The water boatmen are oval in form, in color, a greenish gray and black. They are small insects, none more than half an inch in length. While swimming, the back is uppermost, and the long hind legs serve the purpose of oars. These creatures are able to stay below the surface of the water for a considerable length of time. The structure of the body of the back swimmer is somewhat peculiar. If one of these insects is observed carefully, it will be noticed that the back is shaped

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like a boat. The hind legs are long, flattened, and fringed with hair-like projections. These long appendages assist the insect in swimming. They swim with the back down, always. Frequently, they will remain at the bottom of the brook for long periods of time. This peculiar habit, on the part of these two insects, of remaining below the surface of the water, is not fully understood. It is known that air clings to their bodies in the form of bubbles. These are found under the folded wings and also on the under side of the body. The observation of the instincts, habits, and other types of behavior of aquatic insects, opens up a wide, varying, and profitable field of nature study, which, if properly pursued, will lead to results that might possess elements of scientific importance and of economic value.

No nature study work in the springtime of the year would be complete without the consideraton of its aesthetic side. The colors of the flowers, the sounds of the brooks and of the waterfalls, the songs of the birds, and the scents of the woodlands all have their place in an appreciation of the beautiful in nature, as reached through the senses. This phase of the subject, if it arouses true and rightful emotions, tends to develop more harmonious relations between the individual and the environment, and is, in all probability, as valuable in its development of the self as is the more strictly intellectual study of nature. Any scheme of nature study that does not entertain a proper consideration for the purely aesthetic aspect, just to that extent falls short of presenting a most necessary and vital phase of training in individual development.

UNIVERSITY OF CHICAGO.

Alumni and students of the University of Chicago are in the Army to the number of approximately 1,200. About seventy-five of the faculty are engaged in war service, either in the Army or in other services directly connected with the prosecution of hostilities. One of the faculty, Major Henry Gordon Gale, who is Professor of Physics and Dean in the Colleges of Science, is now in France, and one of the University Board of Trustees, Mr. Francis W. Parker, has charge of important work with the Young Men's Christian Association in the American camps in France. The scientific laboratories of the University, which were at once placed at the service of the Government on the outbreak of war, have been doing much important work since.

ERRATUM.

The following should have been inserted in connection with Figure 6, Dr. Cole's article, on page 453 of the May issue of this Journal.

Figure 6. Inheritance of wilt resistance in flax. At left, the resistant parent; at right, susceptible parent (only a few plants left, and these are sick); in the middle, the vigorous resistant cross between the other two.

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SOME PRECISE METHODS OF FOCUSING LENSES.

By LeRoy D. Weld,
Coe College, Cedar Rapids, Iowa.

In the course of some recent experimental research with polarized light,[1] the writer had occasion to calibrate the focus of an optical instrument for varying wave length with particular care, in order to eliminate the error due to a sort of parallax which gave trouble when the photographic plate was slightly out of focus. It was, in fact, this very parallax which was utilized for the purpose of adjusting the focus in the former of the two methods herein suggested.

The method depends simply on the crossing of the rays of the convergent light at the focus of the lens, the light which is to one side of the instrumental axis in front of the focus being on the other side of it back of the focus. The ordinary method of obtaining the focus by judging the sharpness of an image, while satisfactory for many visual purposes, is not precise at best.

I. To Focus Upon an Object—Broken Prism Method.

If the lens or lens system is to be used to form a real image of a sharply defined object, as an illuminated slit or cross hair, the problem is to find the exact location of that image. For example,

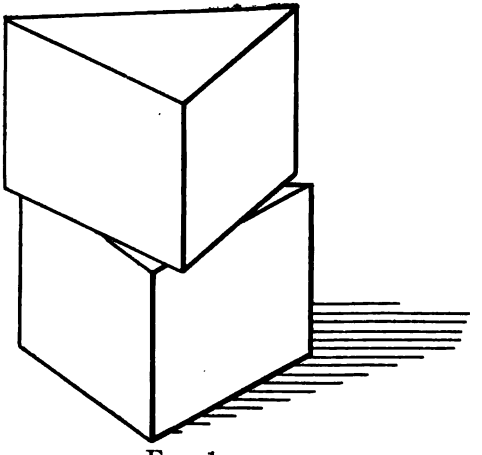

Fig. 1

in the writer's research apparatus, the lens, which was of quartz, with a 30 mm. aperture, had a focal length of about 19 cm., and the object was an illuminated hair line about 33 cm. distant, whose image was therefore produced about 43 cm. back of the

[1]Weld, *Physical Review*, N. S. XI, p. 249. March, 1918.

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lens. An eyepiece directly back of the plate holder, used for aligning and focusing the instrument, magnified the image on the ground slide, or could be used if desired without the slide, as in a telescope. In either case, it was found that the focus could not be adjusted with certainty within several millimeters by the ordinary method, especially when the illumination was faint, as with deep violet light.

The following device was therefore adopted: Two similar glass prisms with polished faces are placed, one on top of the other, with the corresponding faces making a slight angle (say, two or three degrees), as shown in Figure 1. An approximately parallel beam of light of the wave length desired is reflected from this arrangement into the instrument to be tested, the upper half of the beam from the upper, the lower half from the lower prism, so that the two reflected beams gradually separate, like the nearly closed blades of a pair of shears; and they consequently stream past the cross hair (or through the slit) in slightly different directions.

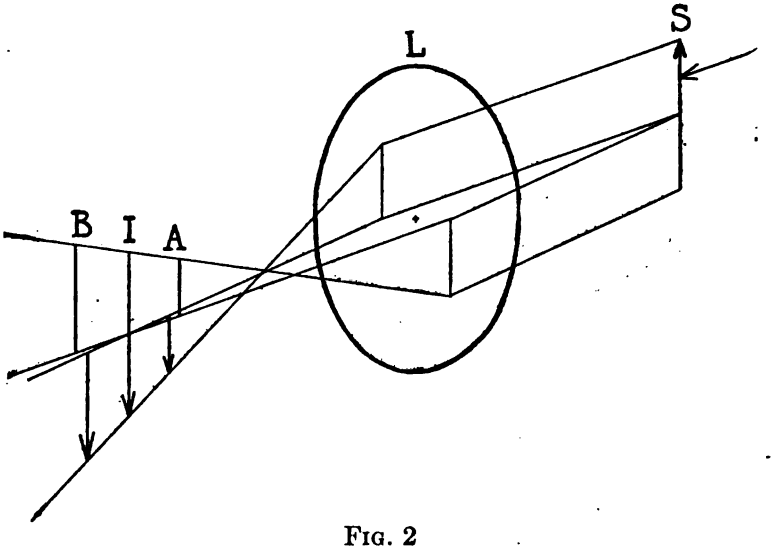

FIG. 2

Figure 2 will help one to trace the paths of the light from this point on within the instrument. An inverted image I of the hair (or slit) S is formed at the focus of the lens L, the upper beam being responsible for the lower half, and vice versa. But at points either a little in front of the focus, as A, or a little back of it, as B, there appears a distinct offset or discontinuity in the linear image, which is in opposite senses in the two cases; so

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that if the screen or eyepiece be moved backward and forward along the axis, the upper and lower halves of the image apparently move to and fro laterally in opposite directions, meeting each other only at the focus (Figure 3).

By this means, the position of the focus may be obtained very accurately. In the writer's experiments, using a focus tube moved smoothly by rack and pinion, the probable error of a single setting was found, from a large number of observations, to be only about .45 mm., and for the average of ten, therefore, only about .15 mm. A very smooth calibration curve was thus obtainable.

The method adapts itself also to cases where the illumination is faint, and to ultra-violet; for by exposing plates at points near the focus, such as A and B (Figure 2), the two false images are obtained, from which, by measuring the offsets on the plates, the position of the true image I can be calculated by interpolation.

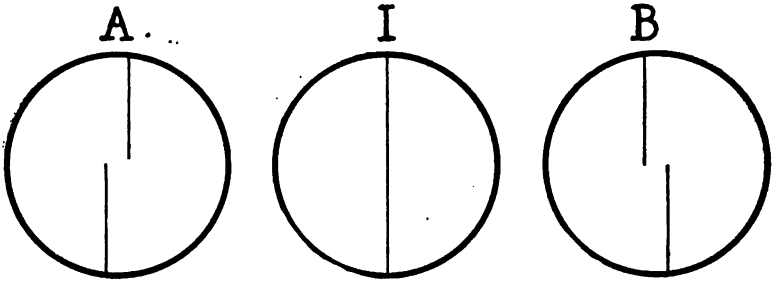

FIG. 3

II. TO FOCUS FOR PARALLEL RAYS.—ANNULUS METHOD.

A modification of the principle has been subsequently employed with lenses which it is desired to focus accurately for parallel light.

In the case of a telescope, there is probably no more accurate way of focusing for infinite distance than that of the sharpness of the image of a star, and (if there is a reticle) the absence of parallax between image and reticle wires. But this method may not always be convenient, and is not adapted to calibration for wave length.

If an accurately calibrated collimator is available, having a narrow slit, the same "broken prism" method can be used by directing the split beam upon the collimator slit, pointing the instrument to be adjusted into the collimator, and focusing it so that no offset appears in the slit image; for then the colli-

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mator objective and the other lens act as a single lens system. Or, conversely, if one has a telescope accurately calibrated for parallel light, the collimator can be adjusted by the same device.

But the modified method above referred to assumes no calibrated instrument. It requires, however, a bright beam of accurately parallel light, as from the sun; or such a beam may be more conveniently obtained by focusing the condensers of a stereopticon upon a small pinhole and then adjusting the objective beyond until a strictly cylindrical beam results. This may be tested by noting that if two parallel wires be placed in it, the distance between the centers of their shadows on a screen remains sensibly constant as the screen is moved to and fro along the beam. Various wave lengths can be obtained by placing suitable color screens before the pin hole.

FIG. 4

A small opaque screen is now prepared having a narrow, annular opening, as in Figure 4, somewhat smaller in diameter than the aperture of the lens to be tested. It may be cut from sheet metal or cardboard, or drawn with dividers on smoked glass. The lens is mounted in the monochromatic, parallel beam and the annular opening placed centrally in front of it, so that a thin, cylindrical shell of light enters the lens parallel to its axis. The lens transforms the cylindrical shell into a cone, whose apex is the focus. A translucent screen placed in this cone will show a sharp ring at every point either in front of or behind the focus, but at the focus, the ring vanishes to a point—a very pretty experiment, by the way, for elementary students. If an eyepiece is used without the translucent screen, the ring will shrink to a point when the focal plane of the eyepiece coincides with the focus of the objective. It should be stated, however, that somewhat better results are obtained when it is possible to catch the image on a screen.

This method has been used by the writer for testing the

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figuring of a lens for spherical aberration; for by using annular openings of different diameters, the lens is tested at different radial distances from its center, and the spherical aberration revealed by a variation in focal length. If only one test is made, it is well to have the diameter of the annular opening about .7 that of the lens aperture, thus making the lens areas within and without this circle about equal, so as to approximate an average focal length.

As an illustration, the writer calibrated for parallel light, by this "annulus" method, a glass lens of 45 mm. aperture and focal length about 20 cm., and found the probable error of a single setting to be about .6 mm., or .2 mm. for the average of ten settings; which compares favorably with the precision of the "broken prism" method.

It is hoped that adaptations of these two methods may be found useful to experimenters with optical benches, spectrometers, etc., and to optical workers generally.

RESOLUTION ADOPTED AT ATLANTIC CITY MEETING OF EDUCATIONAL PRESS ASSOCIATION.

Whereas, The Zone System for determining the rate of second-class postage established by the war revenue act of October 3, 1917, will greatly increase the cost of publications having a national circulation; and

Whereas, Periodical magazines are one of the most potent factors in education, presenting the best current thought on cultural, political, and economic lines, and supplementing the work of the schools and colleges; and

Whereas, The Zone System of postage increase will hinder the free, and easy, and even circulation of the best thought of the country to its remote sections; therefore, be it

Resolved, That the Educational Press Association of America, in annual session at Atlantic City, earnestly recommend to Congress that the Zone System be repealed.

FOREST R. MOULTON.

The University of Chicago Board of Trustees has granted leave of absence to Professor Forest R. Moulton, of the Department of Astronomy and Astrophysics, for one year, from April 1, 1918. He is commissioned Major in the Ordnance Reserve Corps of the United States Army, and will have the duty of directing the computation of range tables and all exterior ballistic data connected with trajectories of shell and shrapnel of all calibers, for both low-angle and high-angle fire.

Professor Moulton, who received his Doctor's degree from the University of Chicago *summa cum laude*, is an associate editor of the *Transactions of the American Mathematical Society*, research associate of the Carnegie Institution, fellow of the Royal Astronomical Society and of the American Association for the Advancement of Science, member of the National Academy of Sciences, and honorary foreign associate of the British Association for the Advancement of Science. Among his published works are *Celestial Mechanics*, *Introduction to Astronomy*, *Descriptive Astronomy*, and *Periodic Orbits*.

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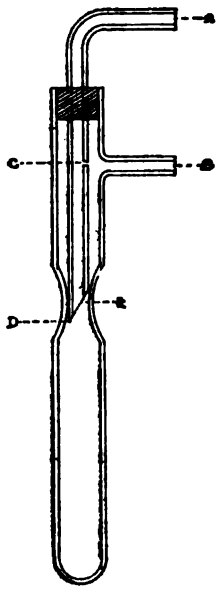
TEMPERATURE CONTROLLER.

By T. S. Huxham,
Montclair High School, New Jersey.

The instrument shown in this drawing is a simple and efficient temperature controller for use in water, oil, or sand bath, or in a drying oven. The materials needed to construct such a controller are: a hard glass side-neck test tube (about six inches by three-quarters) with a one-hole rubber stopper to fit, a piece of glass tubing (about ten inches long), and about three-quarters of a pound of mercury.



The side-neck tube is heated in the middle and drawn to form a constriction (see drawing). The glass tube is sealed at one end and a hole blown at C. This hole is made larger or smaller until it will allow only sufficient gas to pass through to keep the burner, with which the controller is to be used, lit. The sealed end is then cut off obliquely as shown at E. Make a right angle bend at opposite end of tube and fit stopper so that the tube may be adjusted easily.

To operate, fill test tube to D with mercury. Gas enters from top at A and leaves to go to burner at B. Place lower end of controller in bath or oven. When heat expands mercury, the hole E will be closed and only sufficient gas to keep burner lit will pass through C. After a little experiment the controller will be found extremely simple to operate and entirely satisfactory in controlling the temperature.

HIGH-GRADE ABRASIVES.

Tremendous expansion in manufacturing in 1917, particularly in the steel and metal industries, is reflected by the increased production of high-grade abrasive materials in the United States. A preliminary compilation by Frank J. Katz, United States Geological Survey, Department of the Interior, of reports on the production of emery, corundum, and artificial abrasives in 1917 indicates a total of 72,276 short tons, valued at $8,325,312, which is an increase of 33 per cent in quantity and 172 per cent in value as compared with 1916.

The production of emery from the Peekskill district, N. Y., amounted to 14,842 short tons, very little less than in 1916; the production of corundum in North Carolina was 820 short tons, a large increase over 1916; and the production of crude artificial abrasive materials in the United States and Canada, which are largely prepared for use in the United States, amounted to 57,614 short tons, which was 48 per cent more than the production in 1916.

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ROBERT A. MILLIKAN.

At the annual general meeting of the American Philosophical Society, held in Philadelphia on April 18, 19, and 20, Lieutenant Colonel Robert A. Millikan, who is Professor of Physics in the University of Chicago but now of the National Research Council, gave the general lecture in the hall of the Historical Society of Pennsylvania, on the subject of "Science in Relation to the War."

Professor Millikan has now been on leave of absence from the University of Chicago for more than a year, engaged in his work at Washington as executive officer of the National Research Council. As Chairman of the Physics Committee of this body it has also devolved upon Dr. Millikan to organize the scientific work of the Signal Corps, in which corps he holds the position of Chief of the Division of Science and Research. His own detailed scientific work has had to do mostly with the submarine problem and with certain problems in meteorology and signaling. Professor Millikan's volume on *The Electron*, recently published by the University of Chicago Press, has attracted wide attention among scientific men.

A MATHEMATICAL PROGRAM.

The following mathematical program was given with much success by the academy teachers at Baldwin-Wallace College, Berea, Ohio.

THE HISTORY OF π.

By Lillian Braun.

The following questions will be considered by the academy mathematics teachers:

1. To prove that you are as old as Methuselah.
2. If the third of 6 be 3, what must the fourth of 20 be?
3. Show geometrically that $1 = 0$, and $2 = 0$.
4. Thrice naught is naught; what is the third of infinity?
5. Arrange the figures 1 to 9, inclusive, in a triangle so as to count 20 in every straight line. So as to count 17 in every straight line.
6. When is a number divisible by 9?
7. Arrange the figures 1 to 9, inclusive, so their sum will be 100.
8. Write 24 with 3 equal figures, neither of them being 8.
9. If 6 cats eat 6 rats in 6 minutes, how many cats will it take to eat 100 rats in 100 minutes?
10. Do figures ever lie?
11. Can you take one from 19 and get 20?
12. To prove that $2 = 1$.
13. Can you write 30 with 3 equal figures?
14. Can you add 1 to 9 and make 20?
15. Arrange the figures 1 to 9, inclusive, in a circle, using one in the center, so as to count 15 in every straight line.
16. Arrange the figures 1 to 9, inclusive, in a square so as to count 15 in every straight line.

THE HISTORY OF LOGARITHMS.

By Helen Simpson.

17. If $x^3+y = 11$, and $y^3+x = 7$, what are the values of x and y?
18. I found \$10; what was my gain per cent?
19. What is the value of 100 to the zero power? To the zero root?
20. Express the number 10 by using five 9's in four different ways.
21. To prove that $1 = 200$ and $1 = 2000$.
22. To prove that $-1 = 1$.
23. Do the axioms apply to equations?
24. To how many decimal places has π been worked out?
25. What does a billion mean?

OSCAR L. DUSTHEIMER.

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

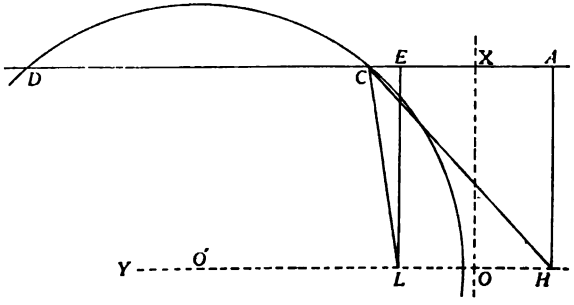
The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

556. *Proposed by L. E. Lunn, Heron Lake, Minn.*

A fast half back finds himself free with the ball 40 yards from the side line. Thirty yards ahead of him is his only opponent, a slower man, whom he knows he can outrun by four feet to three feet. Can he escape? If not, how should he lay his course to gain the most ground before being tackled?



I. *Solution by Ruth A. David, Gibson City (Ill.) High School.*

Let H and L be the respective positions of the half back and his opponent, each 40 yards from the side line AE. HL = AE = 30 yards. If opponent's path and that of the half back's can intersect on the side line (which would prevent his escape), let it be at C. Let n = EC. Let d and $3d/4$ represent the number of yards traveled by the half back and his opponent, respectively. Then

$$d^2 = 40^2+(30+n)^2, \quad \text{and} \tag{1}$$

$$9d^2/16 = 40^2+n^2. \tag{2}$$

From (2),

$$d^2 = \frac{25600+16n^2}{9}. \tag{3}$$

Then from (1) and (3), $n = 70.9$ and 6.25, approximately.

If the half back is less than $(30+6.25)$ 36.25 yards from the goal line, he can escape in a direction which will intersect the side line 36.25

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yards in advance of his initial position. If he is more than 36.25 yards from the goal, his best course is in the same direction.

Discussion by the Editor.

The above solution is the only one received which answers the questions of the problem approximately, and because only elementary algebra and geometry are used in the solution the Editor considers it a credit to its author and publishes it.

A clearer view of the situation can be had, however, by the use of analytic geometry. Consider C a variable point. The locus of the point C under the conditions that CL : CH = 3 : 4 is easily found to be a circle with center O′ (O′L = 38 4/7) and radius equal to 51 3/7. This circle intersects the line AB at C, where BC = 6.25, and at D, where ED = 70.9. The line HC also intersects the circle, as shown in the figure, between H and C, and if the opponent runs in the direction of this intersection the half back will be tackled before crossing line LE unless he chooses another direction. Obviously, his best direction is just outside the tangent to the circle from H. This tangent touches at the intersection of the line LB with the circle 34 yards from L and makes an angle of approximately 48° 35′ with HL. The angle LHC is approximately 47° 50′.

To obtain the locus of C, choose for the origin of coordinates the mid-point O, of the segment HL. Let OX and OY (see figure) be the positive directions of the X— and Y—axes, respectively. Then

$$x^2+(y-15)^2 : x^2+(y+15)^2 = 9 : 16,$$

from which we obtain the equation,

$$x^2+(y-375/7)^2 = (360/7)^2,$$

whence follow the conclusions made in the preceding paragraph.

Geometry.

557. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

If ABC is a triangle inscribed in a circle, and from the middle point D of the arc BC a perpendicular DE is drawn to AB, then AE = ½(AB+AC) and BE = ½(AB−AC).

I. *Solution by Arnold S. Worfolk, Student in Dickinson High School, Jersey City, N. J*

Given: △ABC inscribed in circle O, with D mid-point of arc BC, and DE⊥AB, and AC>AB.

To prove: BE = ½(AC−AB), and AE = ½(AC+AB).

Proof:

Take on AC, AG = AB, and AF = AE.

△DEA = △DFA,

∴ ∠E = ∠F = 90°.

Also △DAB = △DAG,

∴ DB = DG = DC,

and BE = GF = FC = ½GC

= ½(AC−AB).

AE = AB+½(AC−AB)

= ½(AC+AB).

II. *Solution by Murray J. Leventhal, New York City.*

Draw DF⊥AC. If ∠DBA is acute, E lies between A and B, and F on AC produced. From the hypothesis, it is easily shown that triangles AED and AFD are congruent, and DE = DF. Therefore, the triangles BED and CFD are congruent. ∴AE = AF and BE = CF. ∴AB+AC = AE+AF = 2AE. ∴AE = ½(AB+AC). ∴BE = AB−AE = AB−½(AB+AC) = ½(AB−AC).

If ∠DBA is obtuse, then ∠DCA is acute, and by a change of signs and an interchange of letters, the proof still follows.

III. *Solution by Gertrude Buck, Adrian, Mich.*

Given △ABC inscribed in a circle, D the middle point of arc CB, and DE⊥AB, to prove AE = ½(AB+AC) and BE = ½(AB−AC).

Draw AD, CD, DB, and CF⊥AD.

$$\overline{DB}^2 = \overline{AD}^2+\overline{AB}^2-2AB\times AE \quad (1)$$

$$\overline{CD}^2 = \overline{AD}^2+\overline{AC}^2-2AD\times AF. \quad (2)$$

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Since CD = BD,

$$\overline{AD}^2+\overline{AB}^2-2AB\times AE = \overline{AD}^2+\overline{AC}^2-2AD\times AF. \quad (3)$$

Since $\angle CAD = \angle DAB$, $\triangle ACF \sim \triangle ADE$, and $AD\times AF = AC\times AE$.

Substituting in (3) and simplifying, $\overline{AB}^2-\overline{AC}^2 = 2AE(AB-AC)$, whence $AB+AC = 2AE$ and $AE = \frac{1}{2}(AB+AC)$. (4)

But $AE = AB-BE$, then $BE = \frac{1}{2}(AB-AC)$. (5)

IV. *Solution by R. M. Mathews, Riverside, Cal.*

On AB take AF = AC. Draw DC, DA, DF, DB.

$\triangle AFD \cong \triangle ACD$.

$\therefore FD = DC = DB$, and $\triangle BDF$ is isosceles.

Then DE, the altitude, bisects its base, BF.

$\therefore AE = \frac{1}{2}(AB+AC)$

$BE = \frac{1}{2}(AB-AC)$.

This construction has been made the basis for a proof of the law of tangents; see SCHOOL SCIENCE AND MATHEMATICS, XV, *p. 801*.

558. *Proposed by Murray J. Leventhal, New York City.*

From a given point without a triangle to draw a line bisecting the triangle.

I. *Solution by Philomathe, Montreal, Canada.*

Given the triangle ABC and the point P. Draw $PH \perp AB$, $PD \perp BC$. Let $BD = a$ and $PH = h$. To determine the required line PFE, let $DE = x$.

Now, if $2k^2$ represents the area of ABC, we have from similar triangles EBF, EDP,

$$2k^2/hx = (x-a)^2/x^2, \text{ or } x[2(k^2/h+a)-x] = a^2.$$

Hence, to find x, we have simply to construct a rectangle, knowing its area a^2 and the sum of its sides, $2(k^2/h+a)$, a well-known construction. Knowing DE, the line PFE is determined.

Note: These operations can be made on the figure.

II. *Solution by W. W. Gorsline, Crane Tech., Chicago, Ill.*

Given triangle ABC and point P. Required to draw a line from P bisecting the triangle ABC.

Construction:

Through P draw YX parallel to CB, cutting AC and AB produced in Y and X, respectively. Draw a median YR to the side AX, and YZ parallel to PR. Connect ZP, cutting CB at D, and this is the required line.

Proof: $\triangle ARY = \triangle RYX$,

$\triangle PZR = \triangle RYP$.

$\therefore ZPX = \frac{1}{2}\triangle AYX$.

Hence, PZ bisects $\triangle AXY$.

Triangles ZDB and ZPX are similar, and AZDC and AZPY are similar.

Therefore, CB and YX are parallel.

$ZBD/ZXP = ZD^2/ZP^2 = AZDC/AZPY$;

$ZBD/AZDC = ZPX/AZPY = 1/1$. (ZPX = AZPY.)

Therefore, ZBD = AZDC.

$\therefore ZP$ bisects $\triangle ABC$.

559. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle, having given a side, an angle adjacent to it, and the difference of the medians through its extremities.

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Solution by Nelson L. Roray, Metuchen, N. J.

Let $\angle B$ = the given angle, a = the given side, d = difference of medians.

Then we have:

$$m_c = \tfrac{1}{2}\sqrt{2(a^2+b^2)-c^2}.$$

$$m_b = \tfrac{1}{2}\sqrt{2(a^2+c^2)-b^2}.$$

$$b^2 = a^2+c^2-2ac\cos B. \qquad (1)$$

$$\tfrac{1}{2}\sqrt{2(a^2+b^2)-c^2}-\tfrac{1}{2}\sqrt{2(a^2+c^2)-b^2} = d. \qquad (2)$$

From (1) and (2) we get

$$c = \frac{a\cos B(9a^2-4d^2)\pm\sqrt{a^2\cos^2B(9a^2-4d^2)^2-(9a^2-4d^2)(a^2-4d^2)(9a^2\cos^2B-4d^2)}}{2(9a^2\cos^2B-4d^2)}$$

A value that can be constructed. Hence the triangle is determined (two sides and angle they form).

560. *Proposed by I. N. Warner, Plattesville, Wis.*

Show that the following construction does, or does not, give a regular pentagon.

To a given side AB construct RP perpendicular to its mid-point, R, and equal to AB. Draw AP and extend it to S, making PS = AR. With A as center and AS as radius draw an arc cutting RP extended, at D. A, B, and D are three of the required vertices, and AB a given side, so that C and E are easily determined by using the compasses. Then is ABCDE a regular pentagon?

I. *Solution by R. M. Mathews, Polytechnic High School, Riverside, Cal.*

$AD = AP+PS = \sqrt{5AR^2+AR} = \tfrac{1}{2}AB(\sqrt{5}+1).$

Thus the sides of the isosceles triangle ABD are proportional to

$$(\sqrt{5}+1)/2 : (\sqrt{5}+1)/2 : 1.$$

Now, the sides of a triangle bounded by two radii and a side of a regular inscribed decagon are proportional to

$$1 : 1 : (\sqrt{5}-1)/2.$$

These two sets of ratios are equal. $\angle ADB = 36°$, and the construction gives a regular pentagon.

II. *Solution by Philomathe, Montreal, Canada.*

In a circle whose radius is r the side of a regular pentagon is $r/2\sqrt{10-2\sqrt{5}}$, and the line corresponding to AD in the figure (called in French the side of the "pentagone étoilé) is $r/2\sqrt{10+2\sqrt{5}}$. The ratio of the two lines is $\sqrt{10+2\sqrt{5}} : \sqrt{10-2\sqrt{5}}$ or $(\sqrt{5}+1) : 2$. Now, in the figure, let $AB = a$, then $AD = (\sqrt{5}+1)a/2$, hence $AD : AB = (\sqrt{5}+1) : 2$. Therefore, A, B, D are three vertices of a regular pentagon.

III. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let $AB = a$, then $AS = a(\sqrt{5}+1)/2$. In triangle ADE, $AD = a(\sqrt{5}+1)/2$, $DE = a$ and $EA = a$. $\cos E = (1-\sqrt{5})/4$, $\therefore E = 108°$. $\therefore C = 108°$. $\angle EAD = 36°$. In $\triangle DAR$, $\cos \angle DAR = (\sqrt{5}-1)/4 = \sin 18°$. $\therefore DAR = 72°$ and $\angle A = 72°+36° = 108°$, and ABCDE is a regular pentagon.

IV. *Solution by C. E. Githens, Supt. of Schools, Wheeling, W. Va.*

Let circle with radius and center A be intersected by line AB at T and S', A lying between T and B. Let $AB = 2a$.

Then $AS = a+a\sqrt{5} = AS'$. $(RS')(RT) = (DR)^2$.

$(a\sqrt{5})(a\sqrt{5}+2a) = DR = a\sqrt{5+2\sqrt{5}}$.

Tangent $RDB = a : a\sqrt{5+2\sqrt{5}} = 1 : \sqrt{5+2\sqrt{5}} = \tan 18°$.

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$\angle ADB = 36°$ and arc $AB = 72°$. $\therefore AB$ is side of pentagon.

As arcs AD and BD are equal, bisecting each would produce the other extremities of the chords each equal to AB.

CREDIT FOR SOLUTIONS.

531. R. Sundaram Aiyar.

551. C. E. Flanagan. (Omitted by mistake in last issue.)

552. Nelson L. Roray, R. M. Mathews.

554. C. E. Flanagan.

556. Ruth A. David, one incorrect solution.

557. E. L. Brown, Gertrude Buck, C. E. Githens, Murray J. Leventhal, R. M. Mathews, Ola McClusky, R. T. McGregor, Philomathe, Nelson L. Roray, Arnold S. Worfolk.

558. E. L. Brown, C. E. Githens, W. W. Gorsline, Murray J. Leventhal, R. M. Mathews, Philomathe, Nelson L. Roray.

559. Philomathe, Nelson L. Roray.

560. C. E. Githens, W. W. Gorsline, R. M. Mathews, Philomathe, Nelson L. Roray.

PROBLEMS FOR SOLUTION.

Algebra.

571. *Proposed by Harold M. Lufkin, St. Andrew's School, St. Andrew's, Tenn.*

Solve:

$$2\sqrt{2x+2} + \sqrt{2x+1} = \frac{\sqrt{12x+4}}{\sqrt{8x+8}}$$

Geometry.

572. *Proposed by Takeshi Omachi, Sendai, Japan.*

Catalan's Theorem: In a quadrilateral ABCD, if the sides AB and CD are equal to each other, the straight line MN passing through the middle points M and N of the sides BC and AD will equally incline to the sides AB and CD.

573. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

From one of the angles of a rectangle a perpendicular is drawn to its diagonal, and from the point of their intersection straight lines are drawn perpendicular to the sides which contain the opposite angle. Show that if a and b be the lengths of the perpendiculars last drawn, and c the diagonal of the rectangle,

$$a^{\frac{2}{3}} + b^{\frac{2}{3}} = c^{\frac{2}{3}}.$$

574. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle ABC, having given the distances of its incentre, circumcentre, and orthocentre.

575. *Selected.*

Prove this theorem from Wentworth-Smith's *Solid Geometry* (Exercises on Book VI) by means of earlier theorems.

If the face angle AVB of the trihedral angle V-ABC is bisected by the line VD, the angle CVD is less than, equal to, or greater than half the sum of the angles AVC and BVC according as CVD is less than, equal to, or greater than a right angle.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

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Science Tests.

Tests on Heat—H1 to H14 inclusive—together with tests on Electricity —E1 and E2—have now (May 1, 1918) been mailed to all the correspondents requesting them. Probably before the June number of SCHOOL SCIENCE AND MATHEMATICS appears, a complete set on Electricity, Sound, and Light will have been sent out. The printing and preliminary testing of this material has proved a very serious task. These tests have attacked only the *numerical problem* in physics. The results, however, are pointing the way to the testing of other forms of ability.

The time required for the physics tests has prevented the work preliminary to printing chemistry tests. It is, however, anticipated that material can be mailed early next fall on chemistry. *Send in your names now.*

Please report your results on physics at once, even if you do regard your work as incomplete or unsatisfactory. Schools will be referred to by number, not by name, except as special permission is requested.

Examination Papers.

Now, address an envelope to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio. Insert your second semester examinations for the Editor of this department. They will be of interest and value to others.

QUESTIONS AND PROBLEMS FOR SOLUTION.

305. *What do you think of this test on heat submitted by Miss Annie Cloyd, Sewickley, Pa.? Thirty-three pupils averaged 85 per cent. Is it too easy?*

1. The mechanical equivalent of heat is.....
2. It was worked out by.....
3. His work was important because it proved.....
4. A calorie of heat is.....
5. Specific heat is.....
6. Specific heat is found by the.....
7. Upon what principle is this method based?
8. The heat of fusion is.....

Its value for water is.....

9. To vaporize one gram of water it takes.....
10. The boiling point of any substance is the temperature at which .....
11. Give two instances where water boils at a lower degree than 100°.
12. Explain fully why a mixture of ice and salt freezes cream.

306. *Submitted by W. F. Roecker, Boys' Technical High School, Milwaukee, Wis.*

Solve 10 questions from this list. How long did it take you? Is the examination too long or too short?

TRADE PHYSICS: MECHANICS AND HEAT.

1. A differential pulley has wheels of 6 inch and 5 3-4 inch diameter, respectively. (*a*) What is its mechanical advantage? (*b*) If it requires a force of 500 pounds to lift the front end of an automobile, how great a force must be exerted on the chain of this pulley to raise that part of the automobile, the efficiency being 30% under this load?
2. An automobile tire contains 1500 cubic inches of air at 12° C., and a pressure of 90 pounds per square inch. Driving the car causes the air in the tire to be heated to 33° C. What is the pressure, if the air in the tire now has a volume of 1530 cubic inches?
3. The ice man is supposed to deliver 25 pounds of ice daily. He delivers a piece, $12 \times 10 \times 8$ inches. Are you ahead or short, and how much? Ice has a density of .92 grams per cubic centimeter.
4. The coefficient of linear expansion of brass is .0000187 per Centigrade degree. If the melting temperature of brass is 1692° F., how much must be allowed for shrinkage in making patterns for brass castings?

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5. (*a*) The coefficient of friction between the driving wheels of a locomotive and the rails is .25. How much must the locomotive weigh in order to exert a pull of 20 tons? (*b*) How may friction be reduced?

6. (*a*) Define elastic limit, breaking strength, tensile strength. (*b*) A beam 4 inches wide and 2 inches thick, when standing on edge bends .1 inch per thousand pounds. How much per thousand would it bend when laid flat side down?

7. Explain the action of the fever thermometer; of the electric pyrometer.

8. Discuss the advantages and disadvantages of the hot water heating system.

9. Explain how the thermostat controls the temperature of a room in this school. Diagram.

10. Show by diagram how the gas meter measures the gas consumed. If you should receive a monthly gas bill for $10.35, what checks would you make to determine why the bill is so large?

11. If the water pressure in a city water main is 50 pounds per square inch, and the diameter of the plunger of the elevator is 10 inches, how heavy a load can the elevator lift, friction loss being 25 per cent?

12. The area of the piston of a steam engine is 120 square inches, its stroke is 2 feet, the "mean effective pressure" is 50 pounds per square inch, and it makes 150 revolutions per minute. What is the "indicated horse power"? If the brake test shows that the engine delivers 90 horse power, what is its mechanical efficiency?

SOLUTIONS AND ANSWERS.

287. *Proposed by O. L. Brauer, Selma, Cal.*

To what extent is crystal formation dependent on water of crystallization?

An examination of a few pages of Van Nostrand's *Chemical Annual* showed of 54 inorganic substances for which a crystalline form was given, 22 crystallize with water, 32 crystallize without. A complete tabulation of formulas and form would answer the question in full.

Kahlenberg (*Outlines of Chemistry*, p. 156) calls attention to the fact that, "with water copper sulphate forms the compound $CuSO_4$, $5H_2O$ . . . . . Similarly, with dry ammonia copper sulphate forms the compound $CuSO_4$, $5NH_3$."

295. *Proposed by S. R. Powers, Minneapolis, Minn.*

"We find, as we continue to dilute an electrolyte, that the molecular conductivity increases up to a certain point beyond which it does not change. This might be expected for, at a certain dilution, *all* the molecules are dissociated and a further dilution causes no further dissociation." [Quoted from a recent high school text.]

Is this true? Is 100% dissociation attained?

100% dissociation is not attained. Consult Walker's *Physical Chemistry* (The Macmillan Company).

301. *Proposed by C. H. Prescott, University School, Cleveland.*

How many calories of heat must be supplied to melt 10 grams of ice?

Is the answer the same when British Thermal Units (B. T. U.) are used? Explain.

Answer by C. Arthur Smith, High School East, Salt Lake City, Utah.

$10 \times 80 = 800$, the number of calories required to melt the ice.

The B. T. U. is defined as the heat required to raise 1 pound of water 1° F.

1 pound is equivalent to 454 grams.

1° F. is equivalent to 5/9° C.

$454 \times (5/9) = 252$ cal.

Therefore, 1 B. T. U. is equivalent to 252 cal.

$800 + 252 = 3.17$ B. T. U. of heat required to melt the ice.

254. *Correction by K. H. Fussler is acknowledged.*

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ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for March; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "A Demonstration of Photosynthesis," W. J. V. Osterhout; "The Flavones of Rhus," Chas. E. Sando and H. H. Bartlett; "Conservatism and Variability in the Seedling of Dicotyledons," Edmund W. Sinnott; "Noteworthy Lejeuneae from Florida," Alexander W. Evans.

Geographical Review, for April; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Albania and the Albanians," (one map, eight photos), H. C. Woods; "American Explorers of Africa" (one autograph, two photos), Edwin S. Balch; "The Development of the Philippine Islands" (five photos), H. J. Waters; "The Pampa of Argentina" (nine maps, two diagrams, five photos), Walter S. Tower; "The Influence of Geographical Environment upon Religious Beliefs," R. H. Whitbeck.

Journal of Geography, for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Montana," Grant E. Finch; "The Weather Factor in the Great War: VIII," Robert De C. Ward; "Geography Made Real by Field Study," Jennie Hall; "Some Results of the Location of Australia," S. S. Visher; "The Origin of Petroleum Pools," Edward Steidtmann.

Literary Digest, for April 6; *New York City; $3.00 per year, 10 cents a copy:* "The Battle That May Decide the War: Shipyards Gaining on the 'U'-Boat"; "Our First Year in the War"; for April 13: "The Battle of Picardy Just Beginning"; for April 20: "The Supreme Call to Arms"; for April 27: "Why We Have the Whip Hand: To Make Wages Keep Step with the Cost of Living."

Nature Study Review, for April; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "A Fish Pond for the Farm Boy," J. G. Needham; "The Physiognomy of Fishes," R. W. Shufeldt; "The Weepeckets," Elizabeth D. Wuist; "The Salmon," Jay R. Traver; "A Method of Fish Study for Beginners"; "War and Nature—An Appeal," John Price Jones; "The Proper Treatment for Goldfish—Humane Education."

Photo-Era, for April; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "A Simple Method of Photography," Alfred W. Cutting; "Tanks for the Photography of Objects in Fluids," *British Journal;* "How to Make an Inexpensive Weighing Scale," H. L. Peterson; "Sharp or Diffused?" *Photography;* "Flashlight Work for the Amateur," W. R. Bradford; "Photographs in the Home," *Photography;* "Orthochromatic Plates in the Studio," James Cooper.

Popular Astronomy, for May; *Northfield, Minn.; $3.50 per year:* "The Total Eclipse of the Sun, June 8, 1918" (with Plates XIII and XIV), H. C. Wilson; "Useful Observations at Observatories and Laboratories Outside the Zone of Totality, June 8, 1918," Edwin B. Frost; "The Sun's Eclipse of June 8, 1918: Question," John F. Lanneau; "A Contribution to the Eclipse of June 8, 1918," Joseph Ubach, S. J.; "Contacts and Duration Times for the Solar Eclipse," Martha Mengel; "Duration Times for the Total Solar Eclipse," Francis Ruth Hole; "The Recurrences of Solar Eclipses," F. E. Seagrave; "Report on Mars No. 20," William H. Pickering; "What Was the Star of Bethlehem? (Continued)," Stansbury Hagar; "From Universe to Cosmos," Charles N. Holmes.

Popular Science, for May; *New York City; $1.50 per year, 15 cents a copy:* "Trapping Salmon in the Far North," Christian Leden; "The Richest Food in the World," Hudson Maxim; "Our War Sugar Bowl," John W. Harrington; "Wind, Weather, and the Airman: Cooking Your Meals While You Drive," Albert Marple; "Letting Gasoline Do It: Grading Machine Does Work of 125 Men"; "Homes for War Workers," John W. Harrington; and scores of other splendid articles. Send for this issue.

Review of Reviews, for April; *New York City; $3.00 per year, 25 cents a copy:* "Russia's Mutilation—Germany Unmasked," Frank H. Simonds; "Our Navy in the War," Hon. Josephus Daniels, Secretary of the Navy; "Motor Trucks to the Rescue," Harry W. Perry; "The National Non-

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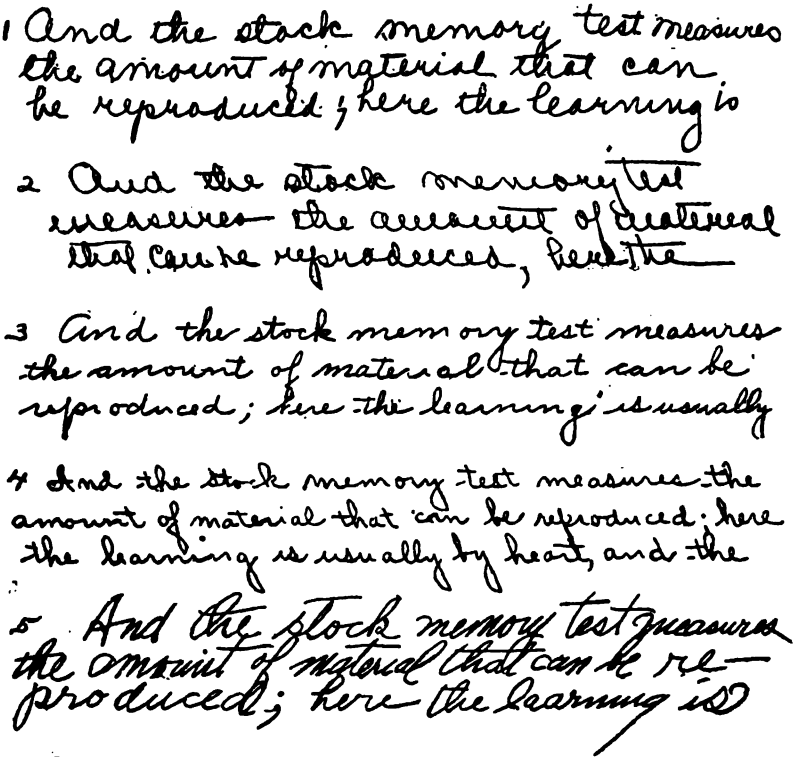
partisan League," John Thompson; "The Glorious City of Bagdad," John P. Peters; "Russia and Japan," K. K. Kawakami.

School Review, for April; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "A Statistical Study of the Junior High School from the Point of View of Enrollment," Paul C. Stetson; "With Eyes They See Not," Mary Jenness; "Semester Reorganization and Program-Making in the Central High School of St. Paul, Minnesota," A. G. Meier; "Supervised Study in High School," G. W. Willett; "Extra Curricular Activities in High Schools," Hazel M. Harwood; "The Curriculum of the Modern Six-Year Secondary School," L. C. Ward.

School World, for April; *Macmillan Company, London, Eng.; 7s. 6d. per year:* "The Arithmetic of Citizenship, II," T. P. Nunn; "The Use of Books in American Schools," Hilda J. Hartle; "Some Thoughts on Science Teaching in Schools," W. A. Herdman; "Science in Secondary Schools: British Association Report."

ERRATUM.

On page 408 of the May issue the half-tone shown below was inadvertently omitted. The six lines immediately under the graph on page 409 should have been omitted as they appear on the reproduction here given.


1 And the stock memory test measures the amount of material that can be reproduced; here the learning is
2 And the stock memory test measures the amount of material that can be reproduced, here the
3 And the stock memory test measures the amount of material that can be reproduced; here the learning is usually
4 And the stock memory test measures the amount of material that can be reproduced. here the learning is usually by heart, and the
5 And the stock memory test measures the amount of material that can be reproduced; here the learning is
Grade in %
1
2
3
4
5
Grade in terms
Excellent
Good
Fair
Passed
Failure

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SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

The twentieth regular semiannual meeting was held at the Los Angeles High School, April 29, 1918, the following program being given:

GENERAL MORNING SESSION.

(About 110 present.)

Demonstration of scientific films.

Address of welcome—Principal Housh.

Music.

Demonstration of visual education material—H. S. Upjohn, Superintendent of Visual Education for Los Angeles County.

"The Application of Psychology to the Teaching of Science"—Address by Dr. A. Sutherland, Ph. D., Los Angeles City Schools, Psychologist.

"The Development of the Airplane"—Address by Major B. M. Woods, Ph. D., Department of Applied Mathematics, University of California, President of the Academic Board of Military Aeronautics.

Business meeting.

AFTERNOON SECTION MEETINGS.

Mathematics Section.

"Mathematical Notes for an Enlisted Man, Coast Artillery"—Address by Mr. Hugh C. Willett, Professor of Mathematics, University of Southern California.

"Experiences and Methods in Teaching Mathematics and Engineering to Men Preparing to Be Officers in the U. S. Navy"—Address by Lieutenant H. E. Carse, U. S. N. R. F.

Earth Science Section.

Excursion to the La Brea fossil pits, under guidance of Dr. J. Z. Gilbert, one of the discoverers and early workers of the Pits.

Physics-Chemistry Section.

"New Ways of Doing Old Things"—Demonstrations by various members of the section.

Visits to the laboratories of the new Los Angeles High School.

Biology Section.

"The Kelp Industry and Munitions Manufacture"—Address by Mr. N. C. Crandall, Manager of the University of California Marine Biological Station at La Jolla, Federal Fish Commissioner for the South Pacific Coast.

In the course of their talks, Dr. Woods, Professor Willett, and Lieutenant Carse laid emphasis upon the fact that recruits are needed who know how to study effectively, and they urged the high school teachers present to require of their pupils concentration, thoroughness, and speed in studying.

The demonstration of materials from the Los Angeles County Visual Education Bureau included films and sets of scientific slides (about thirty slides in a set, with notes) on such topics as astronomy, American birds, anatomy, tuberculosis and housing studies, aeroplane studies, California tree studies, forestry, concrete, volcanoes, and earthquakes, story of the ice age, animals of the past, X-ray studies, subway and tunnel construction, submarine, industries such as rubber, glass, fisheries, leather, skyscrapers, cotton, silk, iron, and steel, brick, coal mining, and meat packing. The majority of the sets are prepared in the County Bureau laboratory, which is also the centre for exchange of films, industrial exhibits, maps and charts, etc., etc.

At the business meeting the Association voted to buy a Liberty Bond.

HARRIET S. KING,
Secretary.

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BOOKS RECEIVED

Laboratory Manual to Accompany Foundations of Chemistry, by Arthur A. Blanchard, Massachusetts Institute of Technology, and Frank B. Wade, Shortridge High School, Indianapolis. Pages vi+203. 19×24 cm. Paper. Loose leaf. 1917. 52 cents. American Book Company, Chicago.

A Textbook of Precious Stones—For Jewelers and Gem-Loving Public, by Frank B. Wade, Shortridge High School, Indianapolis. Pages xii +318. 14×20.5 cm. Cloth. 1918. $2,00. G. P. Putnam's Sons, New York City.

The Third and Fourth Generation, by Elliot R. Downing, University of Chicago. Pages xi+164. 13.5×19.5 cm. Cloth. 1918. $1.00. University of Chicago Press, Chicago.

The Laboratory Study of Chemistry, by Herbert R. Smith, Lake View High School, Chicago, and Harry Mess, Senn High School, Chicago. Pages xiv+256. 21×25 cm. Paper. 1918. Henry Holt & Company, New York City.

Advanced Algebra, by W. C. Brenke, University of Nebraska. Pages vii+196. 14×21 cm. Cloth. 1917. $1.25. The Century Company, New York City.

Elements of Trigonometry, with Tables, by W. C. Brenke, University of Nebraska. Pages vi+121+39. 14×21 cm. Cloth. 1917. $1.25. The Century Company, New York City.

Carnegie Foundation for the Advancement of Teaching, Twelfth Annual Report, by the President and Treasurer. Pages vi+154. 18.5×25 cm. Paper. 1917. 576 Fifth Ave., New York City.

Principles of Bookkeeping, Introductory Course, by George W. Miner and Fayette Elwell. Pages viii+556+xx. 15.5×25.5 cm. Cloth. 1918. $1.30. Ginn & Company, Boston.

Addresses and Proceedings—Fifty-fifth Annual Meeting, National Education Society. Pages ix+864. 16×23.5 cm. Cloth. 1917. Published by the Association, Washington, D. C.

Carnegie Foundation for the Advancement of Teaching, Federal Aid for Vocational Education, by I. L. Kandel. Pages vi+127. 18.5×25.5 cm. Paper. 1917. 576 Fifth Ave., New York City.

Junior High School Mathematics, by William L. Vosburgh, Boston Normal School, and Frederick W. Gentleman, Mechanical Arts High School, Boston. Pages x+212. 13×19 cm. Cloth. 1918. 90 cents. The Macmillan Company, New York.

Infinitesimal Calculus, by F. S. Carey, University of Liverpool. Pages x+352+iv. 14.5×22 cm. Cloth. 1918. $3.00. Longmans, Green & Company, New York.

The Vocational Education of Girls and Women, by Albert H. Leake, Inspector of Manual Training and Household Arts, Ontario, Can. Pages xix+430. 13×19.5 cm. Cloth. 1918. $1.60. The Macmillan Company, New York City.

The Teaching of Agriculture, by Aretas W. Nolan, University of Illinois, and Agricultural Editor of SCHOOL SCIENCE AND MATHEMATICS. Pages ix+277. 13×19 cm. Cloth. 1918. $1.30. Houghton, Mifflin Company, New York City.

The Botany of Crop Plants, by Wilfred W. Robbins. Pages xix+681. 13.5×19.5 cm. Cloth. 1917. $2.00. Blakiston's Son & Co., Philadelphia.

Textbook of Mycology and Plant Pathology, by John W. Harshberger. Pages xiii+779. 13.5×19.5 cm. Cloth. 1917. $3.00. Blakiston's Son & Company, Philadelphia.

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Plant Physiology, by Vladimir I. Palladin, University of Petrograd. Translation edited by B. E. Livingston. Pages xxv+320. 15.5×23.5 cm. Cloth. 1918. Blakiston's Son & Company, Philadelphia.

Library Books for High Schools, compiled by Martha Wilson, Supervisor of School Libraries, Minn. 175 pages. 14.5×23 cm. Paper. 1918. 15 cents.

Predetermination of Prices, by Frederic A. Parkhurst. Pages viii+96. 15×23 cm. Cloth. 1916. $1.25 net. John Wiley & Sons, New York City.

The Organization of Thought, by A. N. Whitehead, Trinity College, Cambridge. Pages vii+228. 14.5×22.5 cm. Cloth. 1917. $2.00 net. J. B. Lippincott Company, Philadelphia.

Plane and Spherical Trigonometry, by Leonard M. Passano, Massachusetts Institute of Technology. Pages xv+139. Cloth. 1918. $1.25. The Macmillan Company, New York.

Essentials of Physics for College Students, by Daniel W. Hering, New York University. Pages x+367+31. 15×22.5 cm. Cloth. 1918. $1.75 net. D. Van Nostrand Company, New York City.

Transactions of the Illinois Academy of Science, Tenth Annual Meeting, Knox College, Galesburg, Ill., February 23-24, 1917. 345 pages. 15×23 cm. Paper. 1917. Published by the State.

Language Reform and the Progress of English Peoples, by Dr. Jos. V. Collins, State Normal School, Stevens Point, Wis.

Scientific Method in the Reconstruction of Ninth-Grade Mathematics, by Harold O. Rugg, University of Chicago, and John R. Clark, Parker High School, Chicago. Pages v+189. 17×24 cm. Paper. 1918. $1.00 net. University of Chicago Press.

BOOK REVIEWS.

The Carnegie Foundation for the Advancement of Teaching. Federal Aid for Vocational Education, Y. I. L. Kandel, Columbia University, Bulletin No. 10. Pages vii+127. 18.5×25 cm. Paper. 1917. Also *Twelfth Annual Report, by the President and Treasurer.* Pages vi+154. 18.5×25 cm. Paper. 1917. 576 Fifth Ave., New York City.

The general public knows very little about the efforts the Government has taken to assist in vocational education. The author gives a very complete history of the original agricultural college land grant of 1862, fathered by Senator Morrill of Vermont, and the annual grant of 1890 is splendidly discussed, as is also the grant of 1907. The relation of the Government to the many phases of vocational education is presented in a very thorough and comprehensive manner. The book is a valuable addition to the literature of the history of education.

The *Twelfth Annual Report* gives in some detail the financial condition of the Foundation. Some limitations in administration of its funds have caused the Trustees to consider a plan of insurance and annuities. The subject of pensions in general is pretty thoroughly discussed. Several reports of educational inquiry are given. Part V is devoted to the report on necrology, the treasurer's report is presented, and there is a complete index.

Copies of these reports may be had by addressing the Foundation.

C. H. S.

A Textbook of Botany for Colleges, by William F. Ganong. 595 pages. 13.5×20 cm. Cloth. 1916. $2.00. The Macmillan Company, New York.

An excellent general textbook of botany for college use, or for high school reference. It is published in two parts, bound separately. The

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first part is concerned with the general morphology of leaves, stems, roots, flowers, fruits, and seeds. The second part, about one-third of the book, takes up the morphology of the plant groups in systematic fashion, and a chapter on the ecological classification of plants is added.

The outstanding features of the book appear to be these. It is a truly general botany, constituting a real introduction to the science. It is written from the point of view of the students who pursue the subject as a part of their cultural training rather than as a preparation for a professional botanical career. Thus it "gives more attention to the large and visible aspects of plant nature than to the minute and obscure." The physiology of plants is very intimately connected with their morphology, and physiology is given a prominence that is unusual in introductory textbooks. The book is written with careful regard to the psychology of the college student, and the literary style is most pleasing.

The author has long been known for his interest in the pedagogics of botany, and has possibly given more attention to the psychology of teaching botany in college than has any other contemporary botanist. The present work is worthy of its author in every way. W. L. E.

The Third and Fourth Generation, by Elliot R. Downing, University of Chicago. Pages xi+164. 13.5×19.5 cm. Cloth. 1918. $1.00. University of Chicago Press, Chicago.

This splendid and valuable book has come from the pen of one of our most careful students in nature study as well as in the science of biology. The author has devoted much time in the last fifteen years to a study of the questions discussed in his little book. The volume is not by any means complete, but it is thoroughly up to date, containing much of the matter on the subject of heredity which has been discovered and studied in the last decade. It is not intended to be an exhaustive scientific treatise for the university man, but it is intended primarily for young folk and laymen. The diction is splendid, and the style is interesting, so that the young reader will be attracted at once. There are ten chapters. The type is clear, and the mechanical part of the book is of the highest order. At the end of each chapter there is a set of questions bearing upon the matter treated in that chapter. There is a bibliography of two pages, and a very complete index of four pages. C. H. S.

Education for the Needs of Life, by Irving E. Miller. Pages vii+353. 13×19 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

This is the correct title for this particular book, and if all people who wish to make the most of the education which they can get from books especially, could read and study this particular text, they would be better able to guide their future study into the proper channels for making their lives most successful. The fundamental aim of the book is to discuss and interpret education. Although education is a phase of the life process, this book interprets to the reader precisely what education is and applies it to one's development.

There are only six chapters, under the following heads: "The Biological Point of View in Education" (forty-eight pages); "The Meaning and Aim of Education" (thirty-three pages); "The Child" (seventy-four pages); "The Curriculum" (forty-four pages); "The Principles of Method" (ninety-seven pages); "The Teacher" (fifty pages). The diction is splendid, and the volume is written in such a fascinating manner that the average student cannot help but become interested in its reading. The type is large, and it is printed on uncalendered paper, thus reducing the direct reflection to a minimum. Each chapter closes with a summary, together with a list of books for supplementary reading. There is an index of five pages. Mechanically, the book is well made. C. H. S.

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Problems in General Physics for College Courses, by Morton Masius, Worcester Polytechnic Institute. Pages vi+90. 13.5×21 cm. Cloth. 1917. 90 cents. Blakiston's Son & Company, Philadelphia.

This is a little book containing one thousand problems in general physics, covering all phases of the subject as usually taught in college and university. The book will be found extremely helpful to instructors in this subject, either for examination or for review. The questions are of such a general nature that they require the student to think before he can answer them correctly. C. H. S.

The Natural History of Chautauqua, by Vaughan MacCaughey of the Chautauqua Summer School. 135 pages. 14×21 cm. Cloth. 1917. B. H. Huebsch, New York City.

This small volume will be hailed with delight by the thousands of people who have paid a pilgrimage to the original Chautauqua in western New York. The book is an outgrowth of ten years of natural history study and teaching in the Chautauqua Summer School. It is hoped that the volume will lead many to have an increased desire for nature study work. It is full of valuable information and will teach the reader how to study nature in the place, where he may happen to live. C. H. S.

Chemical Apparatus and Chemicals; Complete Laboratory Equipment for Every Grade of High School, College, and Technical Laboratory; Chemical Catalog No. 94, is the title of a new catalog just put out by the Cambridge Botanical Supply Company.

It is a very attractive book of 176 pages, packed full of meat, and everything that a chemical laboratory needs. Besides the usual index there is on page 4 a table of contents that makes the book very usable. In addition to the regular lists and prices of apparatus and chemicals, it has the following special features: an up-to-date table of international atomic weights, a list of nearly two hundred chemistry lantern slides, lists of apparatus for four of the best known laboratory manuals, a minimum list of general science apparatus selected by the Massachusetts General Science Committee, and very complete lists of Alundum ware and Pyrex glassware.

The book is mechanically well made, printed on a high grade of paper, and reflects credit on this old and reliable house. Every chemistry teacher should have a copy on his desk for reference and use when making out his orders. C. M. T.

A Short History of Science, by W. T. Sedgwick, Biology, and H. W. Tyler, Mathematics, Massachusetts Institute of Technology. Pages xv+474. 15×22 cm. Cloth. 1917. $2.50. The Macmillan Company, New York City.

This book is the outgrowth of a course of lectures given by the authors in the Massachusetts Institute of Technology during the last several years. Of course there are many volumes on the history of science in print, but in most cases they have been written for specialists in particular lines of work. This book is a departure then from most volumes in print, by virtue of the fact that it appeals more especially to the student and general reader, and tells him what the influence of scientific method is and has been in the last one hundred years in molding and directing human events. The authors surely have brought together a fund of valuable information and compressed it into a small space in this one volume. It is splendidly written, and is a valuable addition to historical literature in the field of science and mathematics. There are seventeen chapters and several appendices. There is a very complete index of six pages. At the end of each chapter is given a list of books for reference reading. Every student of history should have this volume in his library. It deserves a wide circulation. C. H. S.

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A Textbook of Precious Stones for Jewelers and the Gem-Loving Public, by Frank B. Wade, Shortridge High School, Indianapolis, Ind. Pages xiii+318. 14×20.5 cm. Cloth. 1918. $2.00. G. P. Putnam's Sons, New York City.

This book has been in the process of preparation for years by this well-known student of precious stones. He has applied his splendid knowledge of chemistry in a very practical way by bringing it to bear upon the nature of precious stones of almost every kind. He has endeavored to present in the most fundamental way the methods which are used in identifying gems. The book will be found to be helpful not only to the dealer in jewels, but especially to the purchaser of the same. If the latter individual has a thorough knowledge of the nature of precious stones, he will not be cajoled into purchasing stones which to the ordinary layman look exactly like the real thing, but which are of little value.

There are thirty chapters in the volume, together with a very complete bibliography. The index, too, is of a nature such that one may find at once without difficulty where various questions are discussed. It is a book which should have an extensive circulation among all people interested in gemology. C. H. S.

Plane and Spherical Trigonometry, by Leonard M. Passano, Associate Professor of Mathematics in the Massachusetts Institute of Technology. Pages vii+141. 13×20 cm. 1918. The Macmillan Company, New York.

This text aims to present trigonometry in such a way as to make it interesting to students approaching some maturity, and to connect the subject not only with the preceding mathematics, but also with the mathematics to follow. Full explanations are given of important principles, but many simple details are left to the work of the student. Positive and negative angles of any magnitude and their trigonometric functions are given at the beginning of the book, and the basic trigonometric identities are derived at once for all angles. The solution of right triangles and related problems are taken up early without the use of logarithms. The number of identities to be memorized is reduced to a minimum. The lists of exercises and problems are numerous and carefully chosen; many of them are taken from analytic geometry and calculus, though no knowledge of these subjects is assumed. Some of the problems have been invented for this book, and all the problems are chosen to show the practical interest and value of trigonometry. H. E. C.

Analytic Geometry, by Edwin S. Crawley and Henry B. Evans, Professors of Mathematics in the University of Pennsylvania. Pages xiv+239. 13×19 cm. 1918. Edwin S. Crawley, University of Pennsylvania.

In compiling this work the authors have endeavored to keep in mind the needs of the average student. As this subject is not easy even for the trained mind to grasp, though it is built on combinations and applications of ideas already familiar, the attempt is made to approach by easy steps so that the student may feel sure of his ground as he advances. Mathematical rigor, however, has been preserved throughout. The examples and problems are good. At the end of each chapter the exercises are divided into two parts—"normal exercises," which are direct applications of the chapter, and "general exercises" for testing the student's grasp of the subject as a whole and of its underlying principles. The chapter on empirical equations gives a very clear exposition of the methods of finding the equation of a curve which satisfies nearly as possible the conditions of the problem. H. E. C.

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Commercial Algebra, Book I, by George Wentworth, David Eugene Smith, and William S. Schlauch. Pages v+266. 13.5×19 cm. 1918. $1.12. Ginn & Company, Boston.

For use in the first year of a commercial high school this book offers some excellent work. The use of letters and other symbols, formulas, graphs, and equations are studied in a way to make them useful in business affairs. A large part of the problems are based on business transactions and reveal the advantages of knowing something of algebra. Though much of the formal and nonessential work given in the usual course in algebra is omitted, there is sufficient abstract work to give the necessary drill in handling literal expressions. This book is well worth the attention of teachers in commercial high schools. H. E. C.

Plane Geometry, Revised Edition, by H. E. Slaught, Professor of Mathematics in the University of Chicago, and N. J. Lennes, Professor of Mathematics in the University of Montana. Pages viii+310. 13×19 cm. 1918. Allyn & Bacon, Boston.

The authors and publishers are to be congratulated on the many fine qualities of this revision. It was read with real pleasure as page after page revealed some new and interesting way of presenting the cold facts of geometry. The practical applications to everyday life and the numerous exercises in sight work and experimental geometry disclose to the students the use of geometric principles in constructing buildings, ships, machinery, and the like, and give an excellent approach to the logical demonstration of geometric truths. The simple and direct way of treating areas of polygons and regular polygons is typical of the many improvements that will appeal to teachers. H. E. C.

Laboratory Manual to Accompany Foundations of Chemistry, by A. A. Blanchard, Associate Professor of Chemistry, Massachusetts Institute of Technology, and F. B. Wade, Head of Chemistry Department, Shortridge High School, Indianapolis, Ind. 20x25 cm. Pages, 196. 1918. American Book Company.

This is a new high school laboratory manual, prepared by successful teachers of many years' experience. Although the book is designed to accompany the textbook by the same authors, it can be used with any text. It is arranged on the loose leaf plan, one experiment on each sheet. The book contains ninety-five experiments.

In the table of contents, the experiments are marked in five ways, showing the character of the experiment, whether considered as necessary in the logical development of the course, supplementary, special technical applications, those considered dangerous or too expensive for the average pupil, and demonstration experiments. The subdivisions assist the instructor greatly in laying out his course of laboratory work.

The authors have omitted many of the time-honored stock experiments that are found in all manuals, and substituted others that are more up-to-date and of general practical interest, as well as illustrating chemical principles.

One of the most important features is the use of practical questions in italics at the end of each experiment. These questions make the student think, and serve to retain in his memory as no other way can the important facts observed and the principles illustrated by the experiment.

The laboratory directions are very clear, definite, and understandable by the average high school pupil. A minimum of explanation will be required of the instructor.

The manual reflects great credit on the authors and is one of the best laboratory manuals on the market today. C. M. T.

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Science for Beginners, by Delos Fall, Albion College. Pages ix+382. 14×19 cm. Cloth. 1917. The World Book Company, Yonkers on Hudson, New York.

No one is better qualified to prepare a book of this description for use with high school pupils in matters of general science than the author of this splendid book. It covers the whole range of subjects that are usually taught in a course in general science. There are thirty-four chapters in the book. It is written in a manner which will at once secure the attention of the boy and girl. The method of presentation and the very suggestive drawings and cuts are such as to make the book one of the very best which has ever been printed. There are 231 illustrations, most of them new and original. There are numerous exercises scattered throughout the text. The major paragraphs all begin with bold-faced type, which gives the cue to the matter discussed in that paragraph. It is a book that is worthy of an extensive use, and doubtless it will have a wide and ready sale. There is a very complete index appended. C. H. S.

Laboratory Study of Chemistry, by Herbert R. Smith, Lake View High School, Chicago, and Harry M. Mess, Senn High School, Chicago. Pages xiv+256. 21x25 cm. Paper. 1918. Henry Holt & Company, New York City.

Current educational literature contains many articles on "supervised study" and "teaching pupils how to study." For some time teachers of science have contended that laboratory work is one of the best forms of supervised study. Too often, however, laboratory manuals are written to accompany a text in which are found such abstract statements and mature conclusions which might better be developed by the pupil through his laboratory experimentation. The greatest value in laboratory work lies in its training in the method of effective problem solving.

The Laboratory Study of Chemistry will meet the demands of those teachers who believe in the laboratory method of approach in studying chemistry. For those who believe in the textbook method, this manual will furnish "food for thought." The reviewer considers it the best chemistry manual published, for both teacher and pupil, as far as the method of presentation is concerned.

The descriptive, practical, and historical introductions to the experiments arouse the desire of the pupils to undertake the laboratory exercises. These introductions do not, like most texts, present the answers to questions and conclusions of experimentation which the pupils may gain for themselves through reflective thinking on the results of experimental work. They do give the pupil a viewpoint, suggest problems to be solved, and encourage the scientific attitude. Excellent references to supplementary reading material are found with each experiment.

The directions for the pupils' laboratory work are carefully prepared and have been used by the authors with satisfactory results. They are printed on perforated sheets and not numbered. This allows for their use with any textbook and in any order desired. Fundamental experiments are starred. Many optional experiments for the apter pupils are given.

The appendix is particularly valuable. It includes classified lists of books for the chemical library; a table of logarithms; usable tabular material on physical constants, solubility, composition of alloys; an excellent list of reagents and solutions with their formulas and suggestions for preparation of the solutions; etc.

Every teacher of chemistry and teachers of other sciences should examine this valuable contribution to the method of secondary science teaching. C. J. P.

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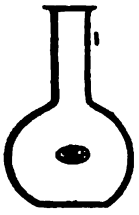

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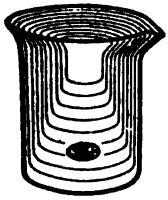

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Your subscription to SCHOOL SCIENCE AND MATHEMATICS has expired. The subscription price of this magazine alone is equal to your annual dues in the Association. It is a magazine unique in its field, and we believe is of real value to teachers of science and mathematics. The numbers you have missed will be sent upon receipt of your dues.

You were not present at the Columbus meeting. Those who were there agree that it was an excellent meeting. Since you missed the meeting, we believe that is all the more reason why you should receive the *Proceedings*. These are now ready for mailing.

The newly organized Service Department will appeal to you we hope. This department is at the disposal of our members and their friends. The teaching of both science and mathematics is now in a state of unrest. Through this department we hope to help to fix standards.

The next meeting, in November, is at the University of Chicago. The topic is, "The Educational Demands of an Awakened Democracy." Both the place and the subject will undoubtedly appeal to you.

We hope we have made our point that the Association desires to be of service to you and is in a position to render such service. We want you with us. The Treasurer, John H. McClellan, Harrison Technical High School, Chicago, Ill., will be glad to hear from you.

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A NEW SERVICE DEPARTMENT.

The Central Association of Science and Mathematics Teachers is inaugurating a new department—the Service Department. It has always been the aim of the Association to render service to its members through its meetings, its magazine, and its printed *Proceedings*, but it desires to be of even greater service in the realm of science and mathematics to the individual teacher.

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The purpose underlying the inauguration of this new department is to give the individual teacher, wherever he may be, assistance in solving his problems. D. A. Lehman of Goshen College, Goshen, Ind., Corresponding Secretary of the Association, is the secretary of this Service Department. All inquiries received by him will be referred for answer to various teachers prominent in their lines of work.

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DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become one year old.

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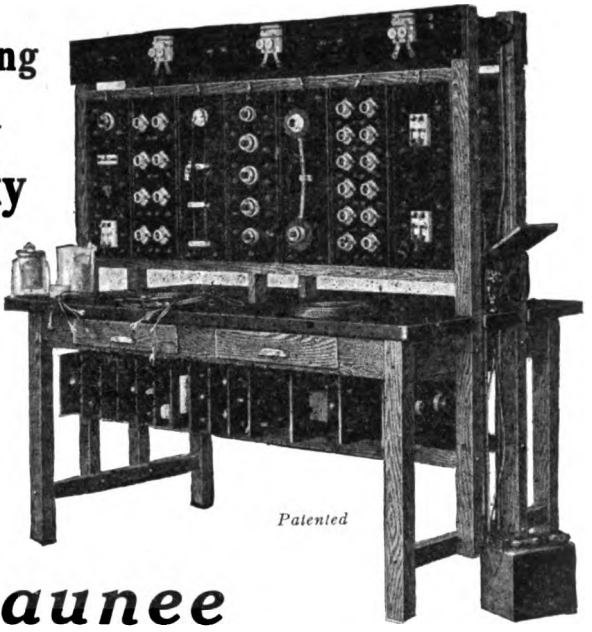

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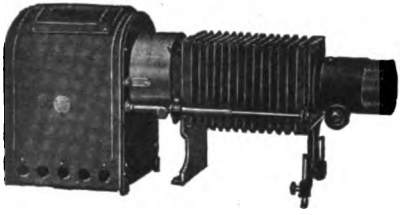

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 7 OCTOBER, 1918 WHOLE No. 153

OPPORTUNITY AND OBLIGATION IN BOTANICAL TEACHING.

BY J. E. KIRKWOOD,

Professor of Botany in the University of Montana, Missoula.

Some years ago a high school graduate entering an eastern university offered botany as an admission unit. The application was accompanied by a certificate of high standing and a decorated book of herbarium specimens. When informed that still more was required to satisfy the committee the objection was met with mingled astonishment and protest. Why should the university refuse to accept botanical work of a high grade, accompanied by tangible evidence? "Very well, let us see if you know the subject," said the examiner. "What is the significance of the green color in vegetation?" To this question there was no reply.

The above incident, which came under the observation of the writer, was typical of the situation that frequently presented itself no more than ten or fifteen years ago. Descriptive botany overshadowed in some places, but in many others entirely excluded, vital features in the life of plants. This was naturally the result of the earlier status of botany in America. Systematic descriptions and the establishment of identity were necessarily the first steps in the development of the science, and the great works of Gray and Torrey, continued by their later disciples, for long years held the main interest in the botanical field. The vast region of the West was but little explored, and every collection was bringing in new and unknown species. Botanical literature was mainly systematic and hardly a thought was given to anything else. The enthusiasm of the masters was infectious and spread widely through schools, and cities, and towns. Circles of nature-loving folk met from time to time, botanical clubs and academies of science (broadening the field to

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include zoology and geology), and various local organizations were formed and in some places are still active.

It has been the attempt of some to belittle this line of popular botanical interest and to charge the lack of general appreciation of botany to the ridiculous aspect it has sometimes displayed in the hands of superficial amateurs. That botany should be regarded as lacking in virility is at best but the superficial snap judgment of incompetent critics. There is no reason why any class of people who can gain an hour of recreation or leisurely enjoyment with the flowers of the field should not do so to their heart's content, or why their devotion to the purely aesthetic aspects of the subject should in any way prejudice its standing in the minds of thoughtful persons. But the attitude here referred to, viz., that of the public toward botany, is but the prejudice of ignorance and is no more excusable than the intolerance sometimes exhibited by the morphologist toward the systematist, or the systematist toward the morphologist, or by the workers in one field of science for those in another.

The devotion to systematic botany of some decades ago awakened an interest in the subject as an avocation in the minds of many professional men and others, some of whom gave it sufficient attention to accumulate valuable collections and to add to the list of plants known to science. Requiring, as it did, so little of expensive laboratory equipment, and with almost endless opportunity for education and enjoyment at hand, it is little wonder that so many found an abiding interest in the plant life of forest and field. Out of this period some emerged from the obscurity of rural communities to conspicuous positions in the history of American botany.

The incident cited in the beginning was significant only as showing the extreme to which the teaching of botany had gone in one direction. That the whole of botany should be in the names of the plants of course led to no immediate economic benefits and to no education of deeply cultural value. The reaction, however, came in the development in Europe and the introduction into this country of the morphological and physiological conceptions founded upon the work of Strasburger, Goebel, Sachs, Darwin, and others. This set forth the dynamic view of life. It revealed the plant as an organism. It awakened an interest in the study of structure, and function, and life history, and several other aspects, including ecology, pathology, and genetics, have since been added.

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But now botanical teaching swung to the other extreme. Descriptive botany languished. Few teachers dared to present it at all in the face of the intolerance of the new school. Text-books appeared from every quarter, presenting courses of study especially for high schools, in which the main body of the text dealt with the microscopic form and structure and more or less complex life histories of strange and little known plants. The subject was usually introduced with a few pages of physiological definitions, and concluded with a brief appendix in which the descriptions of a few common plants were supposed to be given. This vestige, like its vermiform namesake, was to be promptly excised if it showed the least sign of causing irritation. It seldom had the chance to become congested for it was eliminated in advance.

Under this brave system high school pupils of tender years were faced at the start with the compound microscope and preparations of minute microorganisms, and complex transverse sections unrelated to anything before heard of in the pupil's experience, and the connection, if there was any, with life interests of any sort was either overlooked or purposely omitted. The subjects frequently carried the incubus of long and unfamiliar Latin names. Lengthy and laborious laboratory exercises with the requirement of drawings which in the end showed little comprehension of the subject resulted in the removal of botany from the condition of familiar interest to a status conceived as foreign and remote from ordinary human affairs. It might have its application but nobody seemed to know just how, or when, or where. The claim of the disciplinary value of the laboratory method was worked overtime to justify it. One may almost search in vain in the earlier texts for an interpretation of botanical science in relation to everyday human interests.

From the standpoint of the teacher of this period the outlook was not more encouraging. Quickened by the research impetus of German universities, our American professors during the last two or three decades have been busy with investigation and publication, and productive authorship was and is yet almost the only claim to professional recognition. Students seeking their doctorates in American universities were assigned to some narrow research problem, the satisfactory consummation of which was rewarded by the degree. Thus equipped, the newly fledged doctor went forth to teach in high school or college, often with little knowledge of botany beyond the restricted field of his

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thesis. In most cases he knew little about the native flora and cared less. His pupils were not encouraged to seek the names of plants. The teacher was seldom at home in the field and avoided field work with his pupils, who might ask too many questions about the names of things. If he didn't know the name he was ready to reply, "We don't consider the names of plants important; the main thing is their structure and life." This of course is true, but it was not convincing, and usually failed to satisfy or inspire the student.

In the classrooms and laboratories also a radical change took place. No longer the simple equipment of the herbarium, but the costly outfit of microscopes, microtomes, glassware, and reagents that complicated the approach to the subject, increasing the psychological resistance in the mind of the student and deterring school boards and administrators from incurring the expense incident to the equipment of botanical courses, the more especially that their application was allowed to remain more or less obscure.

Taking all these things into consideration, viz., the inadequacy of the textbooks, the incompetence of the teachers, and the expense of the work, it is not strange that botany as a subject for secondary schools has had difficulty in gaining recognition and maintaining its place. Where it has prospered under this system it has perhaps been due more to the personality of the teacher than to the attractiveness of the subject.

So the pendulum of botanical teaching has swung from what one writer of the later school was pleased to characterize as "mere petal-pulling calisthenics" to the other extreme of pedagogical futility, the exaggerated emphasis upon remote and technical details. Within recent years, however, the revival of interest in evolution and the genetic relationships of plants, through the work of De Vries and the mutationists, has furnished a new channel for the botanical current which promises to bring it again within the range of popular appreciation. As soon as the public becomes conscious of the direct connection between botanical science and human welfare, as it bids fair to become by this means, there will be no further debate as to the justification of botany in the schools.

The present tendency in education is all toward the so-called practical considerations. The economic urge is felt everywhere. We must write the dollar mark before anything that we hope to have generally accepted. The few who are interested without

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such influence are effete and effeminate; they are sometimes tolerated but rarely followed. Even the National Education Association is seeking to reduce the material and the time in primary and secondary training merely for the avowed purpose of forcing students earlier through the professional schools that they may hasten their emergence into professions already overcrowded with poorly trained practitioners. It is an undesirable condition, but the virus is everywhere in the blood, and we might as well face it and make the most of the situation. "The impatience of fundamental training," writes the Dean of an eastern graduate school, "is the fundamental weakness in American education and by consequence in American life." While I am far from advocating the study of botany or any other subject purely for its economic advantages, we shall, I believe, be justified in appealing to an economic interest to preserve what is of value from the standpoint of the cultural and the aesthetic as well as the economic.

There are at present few phases of material human interest which have not some connection with plant life; food, fuel, houses, furniture, clothing, books, papers, medicines, and many other articles are furnished in whole or in part by the plant world. Not only, however, in the production of these articles, but also in the loss of them, are we concerned with plants, for the agencies of decay are vegetable organisms, and many of the most widespread and destructive diseases of crops are due to parasitic plants.

It is hardly realized by most people that the heart of scientific agriculture lies in the field of botany, the knowledge of plant physiology as applied to crop production, the knowledge of the principles of heredity as applied to the improvement of crops, and the knowledge of plant diseases as applied to their protection. One-half of forestry is applied botany; silviculture deals with the production and maintenance of the forest. On this production the business of utilization or lumbering depends. Silviculture calls for a knowledge of plants as applied to trees in the forest. Pharmacy is another subject which in its materials and methods is dependent upon a familiarity with medicinal plants, their structure and composition, and a long list of vegetable products which make up a large part of the materia medica, and those which are important both as necessities and luxuries, from tooth powders to spices and oils. From commercial in-

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terests of this sort, it is not far to other industrial relations of plants, as represented by textiles, rubber, etc.

It is, however, in the field of agriculture that the economic importance of botany is most conspicuous. The cultural conditions of crops from the selection of seed to the harvest are inseparable from the principles of plant physiology. The first step in intelligent planting is intelligent selection of seed, and intelligent selection involves several considerations, viz., the size and composition of seeds and their viability or germinating capacity, whether prompt, vigorous, and abundant, or slow, weak, and numerically low. Such determinations are not difficult to make, but the percentage of error is largely reduced when they are conducted by trained hands. That the planting of well-selected seed means improved races of plants and increased yield is one of the oldest established facts in agriculture, but in practice too little attention is given to it even now. How much the yield of grains and other war foods may be increased by proper attention to seed selection is a matter distinctly worthy of attention at the present time.

In the growth of plants from the seed, the relations which their roots establish with the soil particles, the absorption of moisture and its transport through the plant, the quantitative relations of different plants to air and light, the things which effect retardation or acceleration of maturity, the influences which modify or control the fruitage, immunity or susceptibility to disease, matters of pollination and fertilization, all are purely botanical. The line of demarcation between the botanist and the agriculturist is that the former is more concerned with the principles that control plant growth, the latter with their specific application. Why should not the specific application be made in the botanical classroom instead of leaving all the significant phases of the subject to be taken up by the course in agriculture? Already a large part of the botanical field, bacteriology, agronomy, and horticulture, is taken up by men who are dealing with botanical matters but who seldom or never consider themselves botanists. Already the tendency is evident to subordinate departments of pure science to technical schools and to remove them from the field of liberal education, and if this trend is to be checked it will be by making the courses of sufficient breadth and economic significance to interest a large body of people.

But botanical science is not concerned alone with the plant-

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ing and cultivation of plants but with their improvement as well. In this connection I refer to the plant breeders, whose work with the plants of the field, garden, and orchard has laid the world under deep and permanent obligation by giving us the highly developed varities which beautify, enrich, and sustain life. The highly productive races of cereals, the splendid varieties of potatoes and root crops, the delicious fruits are the products of crossing, selection, and propagation. Few plants there are of the farm or garden which in their desirable features have not been accentuated by the botanist in the particular role of the plant breeder. Back of all the concrete and tangible contributions of grains, vegetables, and fruits is the earnest search for the underlying laws which determine heredity, the knowledge of which will enable us to predict with certainty and to execute with precision in dealing with living races and their relations to human interest. Probably at no time in previous history has the industry in this line of investigation equaled that of the present day.

In the work of the plant breeders then, lie inconceivable possibilities for the sustenance of mankind. The first and greatest problem of the human race in all time has been that of food, and the increased productiveness of his fields has been one of man's greatest triumphs over the conditions of his environment. It is this triumph which has made possible the present long-sustained conflict, and the ability further to sustain the struggle will depend largely upon the products of the soil and back of these the intellectual resources as represented by scientific achievement in the realm of the natural no less than in that of the physical sciences.

But in still another phase is the knowledge of botanical science essential. It avails little to plant, and water, and cultivate, and select, if we are to lose the crop by pests and parasites. It is stated on good authority that 133,000,000 bushels of cereals are lost annually through the ravages of preventable diseases. The average farmer probably does not realize that his crop is diseased before the loss has amounted to fifteen to twenty per cent, and it may go to as much as thirty per cent before he will proceed to remedial measures. It is not difficult to see what the loss of so much grain means to the country at large any time, but in the present emergency it is far more than dollars and cents. The public as a rule has no conception of the losses due to plant diseases, and consequently quarantine measures

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and proper safeguards are not readily secured. In the face of present necessity it would seem to be as criminal to allow food crops to be destroyed wholesale as to expose communities to contagious diseases. Crop-destroying diseases are as contagious as any that affect the human body, but the public sense of the importance of crop sanitation is almost as deficient today as it was with reference to personal sanitation one hundred years ago. Here, then, is both the educational opportunity and the obligation at the door of botany.

Cereals, however, are not the only crops depleted by fungi. Blights often ruin potato crops. They attack fruit trees and whole orchards must sometimes be removed. Indeed there is hardly a form of crop plant, or for that matter of plants in nature, which is not attacked by some vegetable parasite. The study of these parasites, the conditions of their life and development, are being studied by botanists and remedies are being discovered. It is now required that barberry bushes be eradicated, inasmuch as they furnished a necessary link in the life habits of certain grain rusts. It is shown that much grain can be saved simply by the elimination of the barberry, and quarantine measures are now generally in force with reference to this plant.

Impressed as we are with the importance of food in winning the war, and urged as we are by the Food Administrator to save at every turn, we are still face to face with the enormous loss due to plant diseases attacking the crops most important from the war standpoint. The recognition of this fact was expressed in no uncertain terms last winter at the meetings of the American Association for the Advancement of Science, and botanical societies have taken steps to see that their fullest powers are enlisted in the present emergency.

While forest products, lumber, etc., are not in danger of immediate shortage to a degree that would endanger the country, nevertheless some very destructive diseases, recently imported, are now at work in the eastern states. One of these has already resulted in the destruction of all chestnut trees over large areas on the Atlantic coast, and the other gaining headway in the white pine woods of Wisconsin and Minnesota, threatens to take disastrous toll of our Rocky Mountain and Pacific Coast forests. Add to this outlook the less extensive but still fatal ravages of some of our native tree diseases, and the fact that wood-rotting fungi are responsible for from seventy-five to ninety-five per cent of the depreciation and loss of structural timbers, and the

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importance of this one group of small plants, the fungi, becomes distressingly apparent.

Instances might be multiplied, and other bearings of botany upon human interest and prosperity might be expanded upon indefinitely, but the above cases will suffice to show how much a knowledge of botany may be of service in popular education. All service which increases and conserves the wealth of the country is at all times a public benefit, and especially if the same service enhances the possibility of equitable distribution of that wealth. In the matter of natural resources the public opportunity is particularly a precious heritage, and it is hard to conceive of a line of educational effort fraught with greater possibilities than is that which deals through the life of plants with the products of the soil.

While material well-being is essential to the enjoyment of large opportunity, it must never be forgotten that the greater benefits are those of the cultural, the spiritual, the aesthetic, the mental depth and breadth of men. It is in this field that the truest national interest lies, even more than in the other, and if at this time it seems to have suffered neglect it is only because in the space allotted to this paper it is sought to set forth the particular urgency of a material concept in relation to botanical education. The knowledge, however, of life in its relation to human existence, in fact, the actual dependence of human life upon plants, is a fact as important in liberal education as any that can be contributed by other subjects in the curriculum. The time would seem to be past when one can lay claim even to ordinary education who is ignorant of facts of such far-reaching and fundamental importance as those which are included in the nature and activities of the plant world.

LIMITATIONS OF THE BALANCE.

B. Blount reports the results of weighings on six balances of the best make (Oertling, Bunge, and Sartorious) made by three people at two different places, over a period of four months, all necessary precautions being taken. Variations of from .4 to 1.6 mg. were observed and could not be correlated with any variation of external conditions. The effects could not be accounted for by any difference in the temperature between the two arms of the beam, nor by the existence of unequal stresses in the arms. Two of the balances had their knife edges set in sealing wax, two had them held by set screws, and in the case of the other two they were apparently pressed in. In all three methods of construction, fortuitous movement of the knife-edge is easily conceivable, thus bringing about an alteration in the effective length of the two arms of the balance, and it is to this explanation that the author inclines.

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It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

SOME PROBLEMS FOR FUTURE SOLUTION.

By B. S. Hopkins,

Division of Inorganic Chemistry, University of Illinois, Urbana.

We recognize the existence of over eighty definite chemical elements among those forms of matter which we are enabled to examine. Some of these are very rare and are known only as curiosities, while others are so common and abundant that they fail to interest the beginner in the study of nature. In his interesting work on geochemistry, Dr. F. W. Clarke gives tables showing the relative abundance of these common elements, and calls attention to the fact that the eighteen most common elements comprise 99.51 per cent of the earth, water, and atmosphere. One would expect all the elements in this brief list to be so common and so thoroughly mastered by the scientists of our day that there would be no problems involved to interest those engaged in research. It is natural to expect that all the unanswered questions in regard to properties and uses of the elements must certainly deal with those sixty-odd individuals whose sum total comprises less than half of one per cent of the planet upon which we live. But let us examine these eighteen elements and see how really familiar they are to us. The second most abundant element is silicon, which comprises over one-fourth of the matter in the world which is known to us. Its compounds have been known and used by mankind since the very earliest times. In such forms as quartz, agate, amethyst, opal, garnet, and beryl it is highly prized and widely admired; in manufactured forms like glass, china, porcelain, and carborundum it contributes largely to the comfort and progress of man. But the element itself has been until recently almost an unknown substance. As late as the year 1900 silicon sold for museum purposes only at a price as high as $4 per gram. Through the development of electrical industries, especially at Niagara Falls, silicon has become available in large quantities and at a very low cost. It was true recently that the producers were

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glad to obtain ten cents a pound for silicon, but it found no sale because no one knew how to use it. It is now being used to a limited extent for removing dissolved gasses from steel and for making certain acid-resisting alloys. But the element is capable of very greatly increased usefulness and as we become better acquainted with this material, which is now available in unlimited amounts and at low cost, we shall undoubtedly find some most interesting and useful properties.

The element standing fifth in the list of common elements is calcium, which constitutes over three per cent of the earth and its envelopes. It is an element which is just emerging from the curio cabinet and finding a place among the useful elements, although man has long used many of its compounds, such as the familiar limestone, marble, alabaster, chalk, gypsum, plaster of Paris, lime, cement, and a host of other everyday substances. The element itself is now produced satisfactorily but only in small amounts and at a cost of something like $3 per pound. This price is certain to be lowered materially as new uses are found for the element and the increased demand stimulates investigation upon improved methods of production. We have almost no use whatever for the metal at the present time, and its influence upon other metals in the formation of alloys is almost entirely unknown. Yet its properties suggest some very interesting possibilities, and this element ought to become a very useful one as soon as we are able to learn how to use it.

Potassium stands seventh in the list of the most common elements. It is neither a curiosity nor is it difficult to obtain, but the outbreak of the war brought American chemists and manufacturers suddenly to a realization of the fact that we have been depending upon Germany for our supply of potash material. It is safe to state that there are as many American chemists today working upon some phase of the potash problem as upon any other one problem of chemical research. The results of this intense effort are showing themselves by the rapid strides made in meeting the demand for potash. A recent statement given out by the Nebraska Conservation and Welfare Commission credits the state of Nebraska with a daily production of more than 400 tons, valued at $60,000, whereas three years ago Nebraska produced no potash at all. In September, 1917, at a meeting of the Portland Cement Association in Chicago, the General Manager of a well-known cement firm made the statement that the profits from the sale of potash from the first year's work in

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potash recovery at their plant had more than covered the cost of the recovery plant and that they were making more money from potash than from cement. Later statements from other cement firms are along the same line and indicate that under present conditions potash is the main product and cement a by-product. Encouraging reports of progress are also made from the efforts to recover potash from the Searles Lake deposits in California, from the alunite of Utah, from the kelp of the Pacific Coast, from the feldspathic rocks of various localities, from the cotton and tobacco stems of the South, from the corncobs of the corn belt, and from a variety of other sources. These problems are rapidly being solved so far as present conditions are concerned, but there will be other and more difficult problems after the war is over and these new industries are brought into keen competition which is certain to come. The solution of these problems is essential in order that America may never again be dependent upon the whim of other nations for its stock of so important a material as potash.

Coming next to potassium in abundance is magnesium, a metal which has been known for over a century. Its compounds are abundant and cheap, its metallurgy presents no particular difficulties, its properties are valuable, yet the cost of the metal and its alloys is entirely out of proportion to the cost of the raw material. Precipitated magnesium carbonate, guaranteed ninety-eight per cent pure, may be bought in carload lots for eleven cents per pound and raw magnesite is priced at $25 per ton. With such prices for the compounds there is no reason why we must pay $3.50 per pound for the metal in the ingot form and why we cannot buy magnesium ribbon at any price. The alloys of magnesium possess properties which would bring them into very general use, but their high cost limits their applications to a few special purposes. We are greatly in need of better metallurgical methods for magnesium in order that it may take its place among the widely used metals.

The tenth element in the order of frequency is titanium, an element which has been badly neglected by chemists. In the free state it is almost unknown, although Berzelius prepared the metal nearly a century ago. It sells at the present time for $5.50 per ounce, while its most common ore, nearly pure TiO_2, may be had in any quantity for less than one cent per ounce. This difference in cost is not due to any scarcity of the raw material, since titanium is found in more than sixty distinct

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species of minerals, some of which are very abundant. Titanium is present in small amounts also in most sands, clays, and granite rock, while it is frequently found in mineral waters, plants, and the bones of animals. The high cost of the elements is due to the fact that no progress in its metallurgy has been made during the past century. There is no doubt but that the metal could be produced at much lower cost than at present, if sufficient stimulus were exerted. There is no demand for the substance, because no one knows how to use it. Consequently the element is neglected and undeveloped through lack of interest and intensive study. Even the use of titanium alloys and compounds has developed slowly, due chiefly to the fact that most of the applications require pure materials, and these are not now available at reasonable prices. The principal use of titanium material at present is in the form of alloys, such as ferro-titanium or ferro-copper, which are used in considerable quantities for removing dissolved gases, especially oxygen, from molten metals like steel or bronze. Some titanium compounds are used in bleaching, mordanting and dyeing of textiles and leather, and in smaller amounts in the ceramic, dental, paint, and abrasive industries. There is every reason to believe that these applications would be greatly extended and many new ones suggested if we knew more about these compounds and their preparation.

Barium is one of the least abundant of the eighteen most common elements, but its compounds are available in unlimited amounts and in very pure form. The production in the United States for 1916 is 200,000 tons, approximately four times the amount mined two years previously. This material, ninety-nine per cent pure, is to be had on the Atlantic coast for $18 per ton. The cheapness and high specific gravity of barytes makes it perfectly natural that this material should be used as an adulterant in the cheapest paints. In spite of the commonness and cheapness of its compounds, barium itself has probably never been prepared in a purer form than ninety-eight per cent. The unusual stability of barium compound as well as the properties of the best barium which has ever been produced, lead us to expect that the element would be extremely useful if it could be obtained at a reasonable cost. The nearest approach, apparently, to a use for metallic barium is in the form of a lead alloy which is being used to some extent in the automobile industry. But this may hardly be considered a beginning to the applications to

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which this metal will be put as soon as we learn how to prepare it and its alloys.

Thus we see that out of Dr. Clarke's list of the eighteen most common elements, fully one-third offer attractive fields for the investigations of the chemist and metallurgist. In many cases the need for more complete information is very urgent, and in all cases the prospect of adding materially to the progress of human advancement is inviting. It is certain that information concerning some of these elements will be one of the results of the present demand for efficiency and the conservation of our natural resources. It is safe to predict that before many years some of these curiosities will become familiar articles of commerce, serving the comfort, preserving the health, or conserving the effort of the human race. If this statement seems visionary it is necessary only to consider the recent history of aluminum. It is the third most abundant element that we know, forming over seven per cent of the earth, and its compounds are found everywhere, and have been used since time immemorial for a great variety of purposes. Aluminum material is said to be "as common as dirt," yet up until comparatively recent times the element itself was entirely unknown. It is recorded on good authority that in 1855 aluminum was sold at the rate of $275 per pound. For a good many years following, the element was a rare curiosity with a price which classed it among the precious metals. In our day aluminum has fallen below twenty cents per pound, and this new metal has taken its place as one of the most useful and valuable products of scientific intelligence and skill. What American brains and determination succeeded in doing for aluminum may also be accomplished in the case of others of the eighteen so-called "common" elements.

These problems are waiting for solution. When these mysteries have been untangled and new forms of material take their places in the commerce of our day, people will wonder how their unfortunate predecessors could have gotten along without these conveniences, just as we today wonder how battles could be fought without airplanes, how artificial lighting could have been possible without the tungsten filament, or how a fire could have been kindled without the friction match.

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CHANGES, PHYSICAL AND CHEMICAL.

By Creig S. Hoyt,
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When a material system is acted upon by some form of energy, we observe a change. That change may be slight and, on the other hand, it may be deep-seated. We have, for convenience in teaching, arbitrarily classified these changes, which we observe in a material system, as physical and chemical. Those changes in matter which are so slight that the energy change is by comparison very great are treated under the subject of physics. Similarly, those changes in matter which are so deep-seated that the energy change is by comparison unimportant are treated under the subject of chemistry.

Such a classification can be considered in no sense categorical. The criteria on which we base our classification are such that a single change might be classified as either chemical or physical, depending on the viewpoint of the observer. At best, the classification is simply an endeavor to roughly divide phenomena, and cannot be considered as fundamental to the science. Its justification lies not in the nature of the science, but in the necessity of the teacher.

From this arbitrary classification, several errors have arisen. Some of these are scientific, some pedagogical. They are due, first, to misconception of the criteria on which the classification is based; and, second, to the habit of considering the classes as categorical and mutually exclusive.

In many texts, the criterion by which one judges whether a change be physical or chemical is evidently the reversibility of the reaction, or, in other words, whether the material be permanently or temporarily altered by the energy change which it has undergone.

"When we notice the things about us, we see that they undergo changes: a piece of wood bends under a weight or warps when wet; a rod lengthens when heated; a piece of iron placed near a magnet attracts another piece of iron. If we remove the weight from the stick, it straightens; the iron removed from the magnet loses its power of attraction. In such changes, although the object may be considerably altered, we still recognize the pieces of the stick as wood, as we do the fragments of a broken tumbler as glass; that is, the material has not lost or changed those peculiar properties or characteristics by which we identify

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it. Such changes are called physical changes; they result usually in a change of such properties as size, shape or color."[1]

It is evident that such a standard would bar from chemical changes some reactions which are easily reversible. It is possible to bring about a chemical change in matter by an application of a form of energy, which can be reversed by the removal of the source of energy. For example, on heating the white solid, ammonium chloride, two gases, ammonia and hydrogen chloride, are formed, but a return to the original temperature causes a reversal of the dissociation with the formation of ammonium chloride. Reversibility affords no criterion of the nature of a change. The polymerization of water on freezing would be physical if viewed from the ease of its reversibility and chemical if viewed from its radical change in properties.

Another standard by which it is judged whether a change be physical or chemical is the loss or gain of distinctive properties. Such a standard might be scientifically correct, provided one chose the right properties. The usual test, however, is that the final substance be recognized as the original material after the application of the energy change. Since distinctive properties may easily be lost or gained without a change in the composition of a substance, the observer may easily be led astray. To conclude that the beginning student will choose the most fundamental properties of a substance rather than the most obvious properties is a mistake pedagogically.

Again, it is a mistake to assume that all changes are either physical or chemical. The phenomenal growth of the relatively new science of physical chemistry is evidence for that statement. The classification of reactions into physical and chemical can not be as rigid as one would be led to believe from the teaching of elementary chemistry. A large portion of chemistry is a refined study in physics. There are many changes taking place as important in their energy aspect as in their material side.

Physical changes are sometimes defined as changes in condition, while chemical changes are changes in composition. We should resort to analysis to establish differences in composition. Yet an analysis would fail to show any change in composition when sodium chloride goes into solution, although two new materials are formed in that process, the sodium and chloride ions. These have properties which differ both from sodium chloride and from the sodium and chlorine of which it is composed.

[1] *First Principles of Chemistry*, Brownlee, Fuller, Hancock, Sohon, Whitsit.

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Molecular association in liquids is another phenomenon which could not be classed as chemical by an analysis, since strictly no change in composition has occurred. Our evidence of it is obtained through surface tension, a physical phenomenon.

An analysis of the content of physics and of chemistry reveals that the systems studied are in most cases identical. The distinction is principally that in physics we are primarily interested in the energy change, as such, while in chemistry we are interested in the change in the material system produced by energy with less attention focused on the energy change itself. The physicist, as a rule, avoids a study of an energy change in a material system where the material change is great, since it tends to make the formulation more difficult. The treatment accorded the Voltaic cell and the new science of radio activity in the physics course shows need for the physicist to abandon his strict classification, and consider material as well as energy change. The older chemistry ignored the energy change and concerned itself altogether with the material change. To such a chemistry, the strict classification might be applicable. The newer chemistry is concerned not so much with tabulating properties and unallied reactions, but with formulating chemical changes according to the energy cause or accompaniment. The change in mass has ceased to be our prime interest. The student of elementary chemistry should be introduced to the modern chemistry and early learn the importance of energy in chemical reactions. Otherwise, chemistry becomes cookery. The present introduction to the science is, then, altogether inappropriate to the subject matter. It has failed to advance as has the rest of chemistry.

Is there need for such a classification? It is not necessary to the science. It is not a true generalization. It confuses rather than aids the student. And, finally, we have no real criterion by which to judge to which category a particular change should be assigned.

ONE OF TYNDALL'S "LIGHT" EXPERIMENTS.

One part gum mastic is dissolved in eighty-seven parts grain alcohol, and a few drops of this solution are added to a vessel of water, while the vessel is vigorously stirred. The gum mastic, being insoluble in water, forms a very fine precipitate which remains in suspension in the water. If the vessel is now viewed against a black background, with the light coming from the side or above, the water can be seen to give a very fair sky blue color, while transmitted light (shown best by placing the vessel between an arc light and a white screen) is a rich golden yellow, like sunlight.

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MAP SCALES.

By R. M. Mathews,
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Military operations are planned and executed with constant use of well-made maps. General Kuropatkin has attributed the failure of some of the operations in the Russo-Japanese War partly to the inability of so many of the officers to read maps; as a consequence the movements of the troops were conflicting and dilatory. Army men say that the best way to learn to read a map is to make one. In the Army schools there are regular courses in which an officer learns to make maps from the simple road sketch, from data determined by pacing or horse trot, to the elaborate topographical maps based on careful surveying operations.

Map making is based mathematically on ratio and proportion, and furnishes some interesting material for concrete applications of the theorems on similar figures in geometry, which is a part of the subject in need of new practical problems. This paper contains some material in the way of theory and problems which it is easy to introduce into the course on geometry with enlivening results.

Explanations.

To get clear ideas about a particular part of the earth's surface we make maps of the land. For each place on the ground there is a point on the map, but the distance between two points on the map is much less than the distance between their stations on the ground.

The scale of a map is the relation of the distance between two points on the map to the distance between their corresponding stations on the ground.

Distance on the ground means *horizontal* distance. Thus the distance between two points on a steep slope is the length of the horizontal line intercepted between the two plumb lines at the stations.

The scale of a map can be specified in three ways:

1. *Verbally*, as 3 inches to the mile.
2. *Numerically*, by a representative fraction (R. F.).

$$\text{R. F.} = \frac{\text{Map distance}}{\text{Ground distance}}$$

When both distances are numbers of the same denomination, the fraction is usually reduced to an equal fraction with unit numerator, as 3 inches to the mile gives R. F. = 1/21120.

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3. *Graphically*, the scale being shown by a line on the map or by a length marked on a ruler.

The first method of giving the scale of a map is convenient in discussions and descriptions; the second is the basis for making calculations; while the third must be used to make maps or to read them. Indeed, graphical scales are of two kinds, namely, working scales, for plotting, and reading scales. A single scale would do if a map were read in terms of the units used for plotting it, but often the distances have been obtained in terms of strides of various lengths, while the map will be used in terms of yards or of miles.

It is needful to be able to express a scale given by one method in each of the other two ways. The simple properties of proportions in algebra and geometry enable us to do so.

All calculation centers around the representative fraction. By definition the representative fraction is an abstract number when the distances on the paper and on the ground have been measured in terms of the same unit. When the distances have not been so measured, then: (1) the measurements must be reduced to the same unit; or (2) the unit must appear as part of the number. To introduce the name of the unit as a factor and to treat it as such, expedites the solution of many problems. The following examples illustrate this statement among other things.

(1) What is the R. F. when the scale is three inches to the mile?

$$\text{R. F.} = \frac{3 \text{ inches}}{1 \text{ mile}} = \frac{3 \text{ inches}}{5280 \text{ feet}} = \frac{3 \text{ inches}}{5280 \times 12 \text{ inches}} = \frac{1}{21120}$$

(2) A foreign map is made on a scale of 2 cm. to the km.; how many inches to the mile is that?

$$\text{R. F.} = \frac{2 \text{ cm.}}{1 \text{ km.}} = \frac{2 \text{ cm.}}{1 \times 1000 \times 100 \text{ cm.}} = \frac{1}{50000}$$

$$\frac{1}{50000} = \frac{1 \text{ mile}}{50000 \text{ miles}} = \frac{1 \times 63360 \text{ inches}}{50000 \text{ miles}} = \frac{1.267 \text{ inches}}{1 \text{ mile}}$$

(3) A man's stride is 64 inches. Construct a graphical scale about 6 inches long which will map his strides in the proportion of 3 inches to the mile.

$$\text{R. F.} = \frac{1}{21120} = \frac{1 \text{ stride}}{21120 \text{ strides}} = \frac{1 \times 64 \text{ inches}}{21120 \text{ strides}}$$

$$= \frac{5.33 \text{ inches}}{1760 \text{ strides}} = \frac{3.03 \text{ inches}}{1000 \text{ strides}}$$

Lay off a line 6.06 inches long and mark it 2,000 strides. Bi-

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sect it and mark the center point 1,000 strides. Divide one part into 10 equal parts (by the regular geometric method) to obtain the length for 100 strides and divide the last of these into five equal parts to show 20 strides.

(4) Correction of erroneous scales. A map was plotted to a scale of 3 inches to the mile from data gathered on the assumption that the observer's pace was 32 inches. After the map was finished it was found that his pace was 30 inches. What is the actual scale of the map? and what length should be taken for 1,100 yards to make a reading scale for it?

The map was actually plotted in the relation 1/21120, that is,

$$\text{R. F.} = \frac{\text{1 pace on map}}{\text{21120 paces on ground}}$$

Had the pace on the map been equal to the pace on the ground the map would have been correct. But the first was 32 inches and the second 30 inches, so

$$\text{R. F.} = \frac{1 \times 32 \text{ inches}}{21120 \times 30 \text{ inches}} = \frac{1}{19800}$$

$$\text{Again,} \quad \frac{x \text{ inches}}{1100 \text{ yards}} = \frac{1 \text{ yard}}{19800 \text{ yards}}$$

$$\frac{x \text{ inches}}{1100 \times 36 \text{ inches}} = \frac{1 \text{ yard}}{19800 \text{ yards}}$$

whence $x = 2$ inches for 1,100 yards.

(5) From a map made 6 inches to the mile the distance AB reads 6,004 yards, whereas AB is known to be 6,000 yards. Examination shows that the 300-foot tape used was too short. How much was it too short, and what is the true scale of the map?

The defective tape is contained in the true distance just as many times as a true tape is contained in the false distance. So, if x be the defective length,

$$\frac{6000}{x} = \frac{6004}{300} \qquad \text{whence } x = 299.8 \text{ feet.}$$

$$\text{Now,} \quad \text{R. F.} = \frac{1}{10560} = \frac{\text{1 tape length for map}}{\text{10560 tape lengths on ground}} =$$

$$\frac{1 \times 299.8 \text{ feet}}{10560 \times 300 \text{ feet}} = \frac{1}{10567}, \quad \text{true R. F.}$$

The "scale" of a map refers always to its linear dimensions, while the "size" of a map means its area. To double or triple the scale doubles or triples the length of each line. To double or triple the size doubles or triples the area, and therefore multi-

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plies the linear dimensions by $\sqrt{2}$ (or $\sqrt{3}$), for the areas of geometric figures are proportional to the squares of their dimensions.

(6) A map made on the scale of 1/21120 is reduced to one-fifth its size in photographic reproduction. What is the new scale of the map?

In the new map, what was 1 inch in the old has become $1/\sqrt{5}$ or .447 inches, and yet corresponds to the same distance on the ground.

$$\text{R. F.} = \frac{1/\sqrt{5}}{21120} = \frac{1}{21120\sqrt{5}} = \frac{1}{47225.5}.$$

A stride is two paces. The advantage of counting strides rather than paces is that the count is reduced one-half. The average length of a person's stride is determined by finding the average number of strides he takes in covering a standard distance at a firm, even walking gait. Have the standard course marked out by measuring a 1,000 feet or so on the street or road by the school.

Problems on Map Scales.

1. Determine the average length of your stride. Pace the "standard distance" each way three times, counting the number of strides for each course. Take the average of these six numbers. Divide this into the known length of the course and obtain the average length of stride correct to the nearest inch.

2. Compute your number of strides for 100 and 1,000 yards and for a mile. Compute your distance in yards for 100 strides. Take the nearest integer as the correct result in each case.

3. Compute the R. F. for maps of 1, 3, 5, 2 3/4, and 6 inches to the mile. Compute the R. F. for maps of 1, 2, 5, and 3 1/2 centimeters to the kilometer.

4. Determine the R. F. for each of the maps indicated by the instructor.

5. Construct your working scale of strides to plot a map at 3 inches to the mile. The scale is to be carefully made on a piece of cardboard about 6 inches long.

6. Construct a reading scale, to use with a map plotted with your stride scale, to give the distances on the map in terms of yards on the ground. Mark this scale on the edge of the cardboard opposite the stride scale.

7. Construct a reading scale of yards to use on a foreign map where the scale is 2 centimeters to 1 kilometer.

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8. Suppose you have a map of a locality but that the scale is not given. Explain how to determine the scale of the map.

9. In hostile country you secure a map of the locality without a scale. 20 inches on the map is the distance between the 20th and 21st degrees of latitude. Determine the R. F. of the map and construct a graphical scale of yards.

10. Find the true scale of a map that was made to be 4 inches to the mile, the pace being supposed to be 35 inches when it was really 36 inches. Is the scale of the map larger or smaller than was required?

11. An officer was ordered to make a sketch on the scale of 3 inches to the mile. This he did, supposing that his pace was 29 inches. Afterward he found that a distance of 4,000 yards scaled from the sketch measured 4,125 yards on the ground. Find his true length of pace and then determine the actual R. F. of the map.

12. A map R. F. = 1/9000 is enlarged to three times its size. What is the new R. F.? How are the linear dimensions changed? If this same map be reduced one-fifth its size, how will the linear dimensions be changed and what is the new R. F.?

13. A map 10 by 12 inches has R. F. = 1/62500. What is the scale if the map be reduced to one-fourth its given size? If the length becomes 9.5 inches in reproduction, is the map enlarged or reduced? What is the new R. F.?

14. A map made to a scale of 1 in 10,000 is reproduced so that 800 yards on the ground scales 875 yards on the map. Was the map enlarged or reduced? In what proportion? What is the correct R. F. on the new map? Give directions for a correct reading scale.

15. The dimensions of a map with a R. F. of 1/63360 is 6 inches by 8 inches. What will be the dimensions of the map of a R. F. of 1/10560? How much is the area increased?

16. A sheet of drawing paper 17x22 inches is to contain a map of a region 8x7 miles, with a border of at least 1 1/2 inches. What is the largest scale that can be used?

INTENSITY OF MOONLIGHT.

With perpendicular incidence from an unclouded sky the intensity of sunlight is about 10,000 candle feet. The corresponding illumination from the full moon is approximately .02 candle foot. Thus the range of illumination between sunlight and moonlight is of the order of 1 to 500,000.

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HOW TO BURN BITUMINOUS COALS ECONOMICALLY.

In order that there shall be the greatest economy in the burning of bituminous coals for heating the different federal buildings throughout the country, the Bureau of Mines, Department of the Interior, has conducted a series of tests with some of the widely used bituminous coals and has printed recommendations based on these tests. Fortunately, the recommendations will also apply to those having charge of private buildings and apartment houses.

The results of the tests are printed in Technical Paper 180, *Firing Bituminous Coals in Large House-Heating Boilers*, by S. B. Flagg. The recommendations on how to burn bituminous coals economically in these large house-heating boilers are as follows:

1. In burning bituminous coals in large house-heating boilers, the fuel bed should not be seriously disturbed until the coal has become well coked, that is, until the gassy part of the coal has been largely driven off.

2. Both caking and noncaking types of coal may be used satisfactorily in boilers of this type if properly handled.

3. The presence of a moderate proportion of screenings mixed with the lump coal causes the fresh charge of coal to heat more gradually and the emission of smoke is kept down more easily. Therefore, such a proportion of screenings is an advantage.

4. Increasing the proportion of screenings in the coal necessitates the use of a stronger draft in order to carry the same load. Smaller firing charges must also be used and more frequent attention given. The tendency of caking coals to cake is increased and this also means that the fire must have more frequent attention.

5. One large charge of coal fired by the spreading method will result in a longer emission of dense smoke than the total emission of such smoke from two charges of half the size fired some time apart and by the alternate method.

6. With some coals, moderate charges fired by the alternate method necessitate less frequent attention to the heater than larger charges fired by the spreading method. Caking coals having a considerable proportion of fine coal or screenings are usually among these. Conversely, a fire will usually require more frequent attention when a lumpy, caking coal, free from screenings, or a noncaking coal, is fired in moderate charges by the alternate method.

7. The number of tests made was not large enough to justify conclusions regarding the relative efficiency with which a coal may be burned by the two methods of firing, but the author believes that in actual service over considerable periods better results will be obtained by the alternate method.

8. Frequency of cleaning the fires will be determined by the character of the coal and the rate at which it is burned, but with most coals the fires should be cleaned only once or twice in twenty-four hours in ordinary weather.

9. If the alternate method of firing is employed, the cleaning should be done just before firing the fresh charge, and only one-half of the grate cleaned at a time. Then little or no smoke will result from the cleaning, because the side of the fire on which there is uncoked coal is not disturbed.

10. All three of the coals fired by the alternate method in the tests described were burned at rates corresponding to the heating conditions during the most of the winter, with scarcely any manipulation of the fuel bed except the cleaning of the fires and an occasional leveling just before firing.

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11. The average fireman is apt to poke and slice the fire much more than is actually necessary. If a caking coal is used and the caked fuel must be broken up before it is well coked, slice the fire by running a straight bar under the fuel bed and raising it slightly so as to crack the caked mass. Do not stir the bed upside down by raising the bar through the fuel bed, nor break the bed with a bar from the top.

12. If the fuel bed is covered with a charge of fresh fuel in a layer more than five inches thick, the new charge, unless it is very free from slack, is apt to have a smothering effect. Then the output of the boiler will be correspondingly decreased and, especially if the spreading method of firing is employed, the mass of fresh coal will usually have to be broken once or twice before the fire will pick up. Consequently, the maximum firing charge should not be much thicker than five inches, and for caking coals containing considerable slack it should not be more than four inches thick. Of course, when a fire is to be kept banked, heavier charges may be used.

13. Do not fire large lumps of coal. Break all lumps into pieces no larger than fist size.

14. Large house-heating boilers do not require an intense draft to meet any reasonable demands for heat if the fuel bed is kept in proper condition, but the draft must be properly controlled.

15. The damper regulator should work freely with changes in steam pressure and should close the swinging draft opening in the ash-pit door before it starts to open the check draft in the smoke pipe.

16. The doors on the front of the boiler should fit snugly in their seats; special care should be taken to prevent any material wedging between the doors and the front and thus admitting air when or where it ought to be prevented from entering.

17. Do not allow clinkers to accumulate in the fire or too great a quantity of ashes on the grates. Be careful, however, in shaking the grates not to shake through unburned fuel.

18. In ordinary or severe weather keep an active fuel bed averaging ten to twelve inches deep. In milder weather the depth of active fuel may be decreased by keeping a layer of ashes on the grate under the live coals.

19. Keep ashes removed from the ash pit.

20. Keep flue surfaces clean by brushing at least once a week.

Copies of this technical paper may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.—[*Bureau of Mines.*

SULPHUR IN ALASKA.

The known sulphur deposits of Alaska are of volcanic origin and lie in the belt of active volcanoes that extends through the Aleutian Islands and Alaska Peninsula. The deposits on Unalaska and Akun Islands and near Stepovak Bay, on Alaska Peninsula, were examined in the summer of 1917 by A. G. Maddren, of the United States Geological Survey, Department of the Interior. The examinations showed that though there is some sulphur at each place examined there is little hope that any of it can be profitably mined at present or in the near future, for the deposits are of small areal extent and are probably shallow, supplies and labor are not at hand, the open season is short, the difficulties of transporting the material from the mines to ships would be great, and the haul to the larger markets would be long. A brief summary of the more important results of the investigation of these deposits has been published and will be sent on application to the Director of the Geological Survey, Washington, D. C.

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GRAPHICAL ALGEBRA AS APPLIED TO FUNCTIONS OF THE nth DEGREE.

By Francis E. Nipher,
Washington University, St. Louis, Mo.

A paper is about to be published by the Academy of Science of St. Louis, with the above title. I present here a somewhat different discussion, which leads to the same results. The difference between the area of two squares, whose sides have a length y and x, is

$$y^2-x^2 = y(y-x)+x(y-x) \qquad (1)$$

The two terms of the second members represent the two rectangles marked a and b in the upper diagram of Figure 1.

If the lengths of the horizontal sides of these squares are increased from y and x to y^2 and x^2, we have the rectangles in the lower diagram of Figure 1. This can be done by laying off from the origin in the upper diagram any distance which is to be

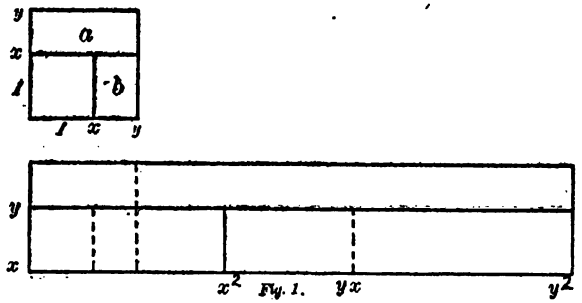

Fig. 1.

adopted as the unit. Draw a line through the point marked 1 on the vertical axis to the point marked x on the horizontal axis. A line parallel to this line through x on the vertical axis will intersect the horizontal axis at a distance x^2 from the origin. Laying this distance off upon the vertical axis, the distance x^3 may be determined.

$$\frac{1}{x} = \frac{x}{x^2} = \frac{x^2}{x^3} \text{ etc.}$$

In this extension of the sides of the two squares to form the new areas, y^3 and x^3, the value of $y-x$ of the first term of Equation (1) has not been changed. The multiplier in this term has been made y times as great. The term has become $y^2(y-x)$. In the second term, the value of the multiplier x has not been changed, but the values y and x in the factor $(y-x)$ have been changed to y^2 and x^2.

As thus modified, Equation (1) becomes

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$$y^3-x^3 = y^2(y-x)+x(y^2-x^2) \qquad (2)$$

The value of y^3-x^3 may be developed by dividing it by $y-x$ and multiplying the resulting terms by $y-x$. In this way we have

$$y^3-x^3 = y^2(y-x)+y\ x(y-x)+x^2(y-x).$$

This equation can be readily changed to Equation (2). The value of yx can be determined by the method of similar triangles as above explained. If now the vertical dimensions in Equation (2) be changed, by multiplying by y and x as before explained, that equation becomes

$$y^4-x^4 = y^2\ (y^2-x^2)+x^2(y^2-x^2) \qquad (3)$$

The two squares $y^2 \times y^2 = y^4$ and $x^2 \times x^2 = x^4$ are shown in Figure 2.

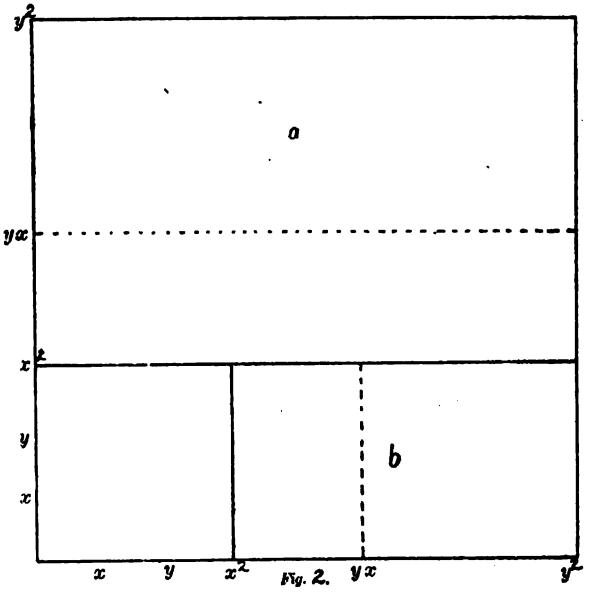

Fig. 2.

The two terms of Equation (3) are there shown to be the two rectangles marked a and b.

Equation (3) may be written

$$\begin{aligned} y^4-x^4 &= y^3(y-x)+y^2x(y-x) \\ &\quad +y\ x^2(y-x)+x^3(y-x) \\ &= y^2(y^2-yx)+y^2(yx-x^2) \\ &\quad +x^2(y^2-yx)+x^2(yx-x^2) \end{aligned} \qquad (4)$$

Equation (4) readily reduces to Equation (3). The first two terms of Equation 4 represent the area a. The dotted line marks the boundary between the areas represented by the first two terms of Equation (4).

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This operation may be continued indefinitely.

The values of $y^n - x^n$ may be represented by areas, whatever the value of n may be. The area, $y^{10} - x^{10}$, may be laid off upon a lawn, by means of white strings, attached to stakes which mark the corners of the various rectangles. If $y = 5$ cm., and $x = 3$ cm., the outer square will have sides 3125 cm. in length.

APPARATUS FOR DETERMINATION OF THE THERMAL COEFFICIENT OF EXPANSION OF GASES.

By W. R. Goddard,
Polytechnic High School, Riverside, Cal.

It is sometimes desirable to demonstrate the determination of the coefficient of thermal expansion of gases with a degree of accuracy which will not require an explanation to the pupils of the sources of error, which if taken into account would give the value as given in their textbook. Such an experiment may be performed with an apparatus arranged like the following:

The figure represents clearly enough what supplies are needed to make it, but a few explanations of the construction of some parts of it will be given.

The capillary tube is about 70 cm. long and has a 1 mm. bore. This is thoroughly cleaned with nitric acid and washed first by drawing a small piece of wet cloth back and forth, then rinsing well with distilled water. It is then attached to a suction pump and air which is dried by bubbling through concentrated sulphuric acid is drawn through while a bunsen flame is played along the tube. When it is thoroughly dry the tube is sealed off about two inches from the end toward the suction pump. While the tube is still hot it is disconnected from the sulphuric acid drying bottle, and a small globule of clean *dry* mercury is quickly placed on the opening. It will be drawn slowly into the tube as the dry air in the tube cools. The mercury globule is then forced about half way down the tube with a fine iron wire which lets the air out as it goes down.

The capillary tube of dry air is then placed in a larger tube about 4 cm. in diameter and 62 cm. long. The upper cork (4) is bored so as to easily slide up and down on the capillary tube without raising it. A two-holed rubber stopper is at the bottom. It contains an outlet tube and a brass cylinder (5) with an open side. The capillary tube is inserted. The open

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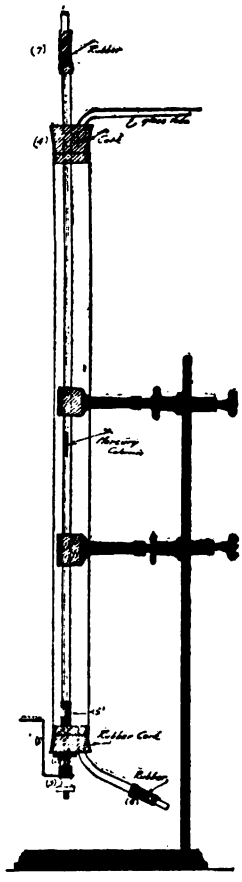
side affords a view of the lower end of the air column. The brass cylinder is made by boring out a piece of brass rod and filing out the opening. It is held in place by a brass rod which is screwed into the bottom and extends about an inch and a half through the stopper. A washer and nut on the outside holds the cylinder in place and makes the connection water-tight. The zero point is located by a piece of double bent sheet brass (1) soldered to a brass guide as shown. The zero point is made level with the lower end of the air column by the thumb screw (3) and held rigid by the brass spring (2).



The operation of the experiment is simple. First set the zero point level with the lower end of the air column. Take off the upper plug (7) from the capillary tube and see that the lower delivery tube (5) is plugged. Raise the upper cork. (4) and fill with finely crushed ice up to the mercury bead. After a few minutes place a meter stick on the zero level and read the initial volume of air (as length). The initial temperature is then zero degrees. Next remove the plug from the lower delivery tube and connect the upper inlet tube to a source of steam supply. Allow the steam to run through. The ice will melt and run out into a convenient receptacle.

When the mercury bead has risen to its highest point and remains stationary, again place the meter stick on the zero level and read the final volume. The final temperature is then calculated as the temperature of steam at the pressure read from a barometer. (2.68 cm. change in barometer reading makes a change of 1°C. in the boiling point of water.)

The calculation of the coefficient of expansion is then made exactly as in the case of linear expansion of metals, using the formula $e = k\,1(t' - t)$, where $t' - t$ is change in temperature, e is

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expansion, k is coefficient, l is length—and substituting in the formula V for l.

Then if it is desired to demonstrate Charles' Law we have only to substitute in the Charles' Law formula, changing the temperature from Centigrade to absolute degrees. Or one may develop the formula from the data obtained.

The following data was obtained by the use of the above apparatus and subsequent trials gave the same readings for the initial and final volumes under the same conditions:

Initial volume of air	24.3 cm.
Final volume of air	33.2 cm.
Change in the volume of air	8.9 cm.
Initial temperature	0°C.
Final temperature	99.5°C.
Change in temperature	99.5°C.
Coefficient of expansion	

$$k = \frac{e}{L(t'-t)} \qquad .00368$$

PROJECTS IN BIOLOGY.

By Grace F. Ellis,
Central High School, Grand Rapids, Mich.

The interesting article on "Projects in Biology" in the April number of School Science suggested to me that possibly some of your readers might find the following outline of work on the same subject of interest. It is used in classes of physiology in the tenth grade, and a hundred students are now at work at it. The general outline is supplemented by whatever project the student is most interested in, and he may prove his points in the discussion which is outlined, by reference to any project carried on by his fellows. I have used most of the experiments outlined in the article and find them satisfactory and interesting to students.

In the final summing up of the work in this subject I shall use the excellent list of lantern slides put out by the Chicago Biological Supply House. I wonder if your readers know it?

Exercise XXV.

Problem: How are bacteria distributed?

Material: Sterilized dishes containing agar for cultures.

Directions: In every experiment count the number of bacteria and mold colonies which appear. Each colony of bacteria grew from a single bacterium. Colonies of bacteria are round, waxy-looking spots. Molds show spores and tiny fibers. When you open your dish notice whether the bacteria and molds have in any way affected the agar.

I. Does dust contain bacteria?

1. Collect a little dust from floor or furniture on a bit of stiff paper and blow it over the surface of the agar in a petri dish. Close the dish at once, seal the dish and cover together, and mark with your name, date, and material.

2. Mount a little dust in water on a glass slide, cover and examine under high power. What does it consist of so far as you can tell? Does it seem to offer a lodging place for germs? To answer this question, mounts of silk, cotton, and woolen fibers and dirt are provided.

II. Do bacteria float in the air?

1. Expose a prepared bacteria dish for two minutes to the air

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of a room. Close, seal, and label as above. The room may be one of the school rooms, or a room at home or in some public building.

2. Compare air in a room with unoiled floor recently swept by a broom; with vacuum cleaning; with one in which sweeping of an oiled floor is being done.

III. Do bacteria exist in the body?

1. Place a measured amount of saliva in a bacteria dish. Seal and label.

2. Scratch a finger nail across the agar and seal your dish.

Written Report.

Use ruled paper, leave margin, use numbers or headings, and report in connected theme form, on the problem which forms your subject.

I. Introduction.

Preparation. Explain how the culture medium and dishes are prepared and why so much care is taken to sterilize everything that is used.

II. Exposure.

How are the cultures exposed to the air and to dust? What does dust seem to be under the microscope? Might dust harbor germs? Is dust dangerous?

III. Results.

Which cultures yield more bacteria, dust or air? What makes the difference in this building (i. e., presence of more bacteria in air or dust)? How should this knowledge affect our treatment of floors in public buildings? Our methods of cleaning? Do you believe in the use of a feather duster? Why?

IV. Bacteria in the body.

Do you find bacteria present on the skin? In the mouth? Are these dangerous? May the mouth harbor dangerous bacteria?

V. Bacteria and disease.

Do coughing and sneezing have anything to do with their distribution? Why are colds contagious? Can you suggest any means of reducing the number of bacteria in the mouth? Why are the nose and throat so often infected?

BACTERIA[1]

By Mary Wilde,

Grade 10-1, Central High School, Grand Rapids, Mich.

I. Introduction.

(a) *Preparation.*—The culture medium which was used was agar, a Japanese seaweed which is a jelly-like substance. This substance was heated until it had thoroughly dissolved; about six hours was necessary for this to take place. The bacteria dished into which this was immediately poured, so that no bacteria could possibly enter, were baked in an oven three times at intervals of twenty-four hours, so that all germs might be killed with the excessive heat. Great care was taken that no fingers touched this, or that breath reached it, so that no germs could possibly enter and that the agar might be absolutely free from germs.

II. Exposure.

(a) *Cultures Exposed to Air and Dust.*—The cultures are exposed to air by leaving them open two minutes, and to dust, by quickly lifting the cover of the dish and blowing in the dust or any other substance with

[1]This is one of the results of the project plan as outlined by Grace Ellis on page 607.

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which you are experimenting. Looking at dust under the microscope it looks to be little particles of dirt and fibers. Dust harbors many germs as I proved with my experiment. For this reason great care should be taken that dust be kept down on the floor instead of flying around in the air. It is my opinion that dust is dangerous, for very likely it carries disease germs.

III. Results.

(*a*) *Methods of Cleaning.*—Dust yields much more bacteria than air, for dust collects on furniture and the like, while air is continually moving. This building has a very small amount of bacteria in the air, for an oily preparation is poured on the floor before sweeping, thus keeping the dust from flying around on other articles and in the air for us to breathe. A vacuum cleaner is the very best article used for cleaning, for it not only collects more dust in the rugs than a broom, but also takes up the dirt so quickly that very little dust collects on the furniture; therefore, it has the same effect on the air that the oil on the floors does. I do not believe in the use of a feather duster, for the dust only flies from one article to another and so of course a great deal of dust is flying around and after one is through dusting the question is asked, "Have you dusted yet"? This is very discouraging.

IV. Bacteria in the Body.

(*a*) *On the Skin and in the Mouth.*—Bacteria are present on the skin and in the mouth, as was tested in the laboratory. The bacteria which are found in the mouth are very dangerous, for they may develop dangerous disease germs such as diphtheria, typhoid, and scarlet fever. With diphtheria the bacteria are mostly in the throat. This disease is more common to children than to grown people, for children are more liable to exchange handkerchiefs, pencils, gum, and the like. Typhoid fever is a disease which is caused only by eating or drinking the typhoid germs. These typhoid germs are found in unfiltered water in Grand Rapids; therefore, it is necessary that the water people drink be absolutely pure.

V. Bacteria and Disease.

Coughing and sneezing with mouth or nose uncovered has a great deal to do with their distribution, for by means of these the germs in the mucus fly to the nearest person, who usually begins to sneeze and before a great while has developed a cold. Colds are contagious, for in coughing and sneezing the germs are spread and many persons are thereby affected. The nose and the throat are very often infected, for by an experiment which was made with a soiled handkerchief and agar, many bacteria are found to reach the nose. Also, an unsterilized toothbrush was given the same treatment with the agar that the soiled handkerchief was, and this also grew many bacteria. In this way the mouth and throat become infected.

VI. The Bacteria Experiments.

To me, there were a great many very interesting experiments about which I would like to tell, but there are too many to mention them all. I think the most interesting was the experiment of agar exposed to the air in a theater. After this had been kept long enough to allow bacteria to develop, if present in it, a great many bacteria had grown. Moral: Do not go to a theater unless you are physically able to kill the bacteria which may enter your body.

VII. Conclusions.

(1) Have clean habits.

(2) Do not drink unfiltered water, that the chance for typhoid fever may be less.

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(3) Sterilize your toothbrush, that your mouth may be as free from germs as possible.

(4) Do not use soiled handkerchiefs, that your nose and throat may be kept free from germs.

(5) Keep physically strong and healthy, as this is "the first service that you owe your country."

AMERICAN NEEDS FOR ENGLISH CLAY.

Most of us think clay is something as common and abundant as sand or gravel. Consequently, it comes as a surprise to be told by the Shipping Board Committee on Mineral Imports and Exports in Washington, that even in this day of great shortage of oceangoing ships we have to import from England every year 200,000 to 250,000 long tons of clay. Last year we imported more than 250,000 tons over the ocean.

Furthermore, a great part of this clay comes over in steamers loaded full and the rest in big steamers loaded with clay up to fifty per cent and more of their maximum carrying capacity. These ships put into Fowey, England, for their freight. To get this clay on and off the boats requires ten days on each cargo. An insignificant percentage of the clay is shipped as ballast. This represents small lots loaded into big liners at Liverpool. But it will be seen that the importation of English clay consumes an important amount of ship tonnage measured in days' time lost because of natural delays incident to the transport of this freight.

Why do our manufacturers pay the high freight rates now necessary in order to obtain an article like clay from England? There is, as we all know, an abundance of clay in this country. A great deal of high-grade clay is produced here, and of a character suitable for pottery, porcelains, and other articles which require clays of special excellence in their manufacture. But not much over half of the clay of this grade that our industries require is domestic. When war broke out in 1914, only a third of it was domestic. We have not been able to develop and equip our deposits fast enough to make these English clay imports unnecessary. In fact, it is doubtful whether we will produce as much high-grade clay in 1918 as we did in 1917. Our manufacturers want the clay, but they cannot get anywhere near as much as they want. The reduced output is due to railroad and operating conditions and is not related to the character or size of the deposits, which are capable of large production.

Domestic producers do not mine their clay quite as cleanly as their English competitors. Nor is the domestic clay as uniform in character. It will not bring the high prices paid for English clay. But more could be sold if it could be produced and carried to its market. Still more could be marketed if cleaner, more uniform clay were produced, for in that event the consumers would use a greater percentage of domestic and correspondingly less English clay in their mixtures.

However, our complete dependence upon English clay continues. We must rely on English clay as a chief ingredient of the dishes we eat from, the paper in our books and magazines, the porcelain in our electric light sockets and half a dozen other articles of less general use.

Fortunately, it is a fact that far less English clay is necessary to proper manufacture of paper than is now used. Besides domestic clay there are many other substances of domestic origin that could be used in the body, not the finish, of this paper. Over half of the English clay we use is consumed in making paper. So that, if a shortage of English clay should develop, it would not be highly serious until the shortage became very great, until there was only half of the normal supply, or less, available.

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MOCK TRIAL OF B VERSUS A, OR SOLVING A PERSONAL EQUATION BY THE JUDICIAL PROCESS.

ADAPTED BY KATHRYN MCSORLEY, HUNTER COLLEGE, FROM MR. STEPHEN LEACOCK'S STORY, "A, B, C."

CHARACTERS.

JUDGE. Man of few words. Speaks briefly and shows no unusual interest in the proceedings.

OFFICER OF COURT. Pompous, feels very important, repeats, demands of judge in ringing tones.

FIRST AND SECOND LAWYERS. Fussy but businesslike, each bound to win the case.

A. Very much alive, great interest in what is going on, with a tendency to bet with second lawyer whenever an opportunity presents itself. A full-blooded, blustering fellow of energetic temperament, hot-headed and strong-willed.

B. A quiet, easy-going fellow. Afraid of A and bullied by him, and quite in A's power having lost all his money in bets. He has gentle, tender thoughts of little C.

D. A tottering old man, inclined to be talkative and tell a great deal more than is asked. Completely at sea when second lawyer fires his volley of technical language, but when first lawyer shows his friendliness he is very eager to please him and tell all he knows.

COURT CLERK.

JURY. Plane Trigonometry, Arithmetic, Algebra, Plane Geometry, Solid Geometry, Spherical Geometry, Differential Calculus, Integral Calculus, Descriptive Geometry, Astronomy, Spherical Trigonometry, Analytics.

(*Judge's stand and desk are up center of stage. Seats for the jury are placed left of the judge. Can put seats for newspaper reporters at right. In front of judge's stand is a table with books, documents, etc., for the attorneys and clerk. A witness stand and a prisoner's box, one right and one left. Court clerk sits at lawyer's desk ready to take notes.*)

(*Officer of the court bows in the judge.*)

Officer—This way, your Honor!

Judge—That will do. (*Goes to desk.*) Go ahead and cry.

Officer—(*Shouts.*) Hear ye! Hear ye! The court is open, for his Honor is here.

(*Enter on the right first lawyer—tall, lean, with books and papers. Collides with officer.*)

First Lawyer—Beg pardon, I'm in a hurry. (*Goes to the table in front of judge's desk.*)

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Officer—If I had bitten my tongue off that time, I'd give you a piece of my mind.

(*Enter second lawyer—another fussy lawyer. Goes to table.*)

Judge—(*Raps.*) Call in the jury from the juryroom.

Officer—(*Calls from list.*) Plane Trigonometry!

(*Enter Plane Trigonometry.*)

Judge—What is your occupation?

Plane Trigonometry—I am a dealer in triangular sines by profession, but largely famous for my tables.

Judge—So you make signs and tables for money?

Plane Trigonometry—No, your Honor, I make tables of sines for articles of torture in the hands of some instructors and for the annoyance of freshmen.

Judge—Go sit down among the jury. Call the next juror.

Officer—Arithmetic!

(*Enter Arithmetic with example of galley method in evidence.*)

Judge—Are you a married man?

Arithmetic—No, Judge, all these scratches come from an old habit of division I can't quite control.

Judge—You have been summoned to be a juror. Do you know the nature of an oath?

Arithmetic—I do, your Honor.

Judge—Give me an example.

Arithmetic—You beast, you dog, you algorismus cipher, you—

Judge—(*Raps.*) That is enough, go sit down among the jurors. Next juror.

Officer—The next calls himself Algebra.

(*Enter Algebra.*)

Judge—What is your occupation?

Algebra—I search the unknown and help solve the most perplexing problems for those who employ me.

Judge—Do you mean that you are a detective?

Algebra—Well, your Honor, I would not call it exactly that. By the same process of reasoning I would be a dentist, for I have the extraction of roots down to a science. But I *am* a person of Harmonical Proportions, vitally concerned in Progression.

Judge—All right. If the lawyers have no objection, sit down. Officer, hurry them along.

Officer—Geometry!

(*Enter the three Geometries—Plane, Solid, and Spherical.*)

Solid Geometry—We are three, your Honor, Plane. (*Introducing Plane Geometry.*)

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Plane Geometry—I am wont to wander about in circles or go off on tangents, but I am usually on the square.

Solid Geometry—(*Introducing other companion.*) Spherical—and myself, a man of substance, a solid citizen—of no particular profession. In the realm of mathematics, however, we might be said to hold a place proportional to that of a conductor of a newspaper society column. We concern ourselves not only with the measurements of magnitudes, but with their various properties and relations as well. We are the personification of logic itself, and follow every hypothesis with a proof, the genuineness of which is established by the addition of my usual signature, Q. E. D., or that of my secretary, Q. E. F.

Judge—That will do. Take your seats among the jury.

Officer—That reminds me, your Honor, we have three jurors sworn in since yesterday. (*Calling.*) Descriptive Geometry, Differential and Integral Calculus. Take your places among the jury. (*These three enter and take seats.*)

Judge—Hurry them in.

Officer—Astronomy!

(*Enter Astronomy.*)

Judge—Have you a profession?

Astronomy—Before the war broke out, your Honor, I dwelt among Hunter students, and entertained them with stories of my travels along the cyclic path and tales of the heavenly bodies I met there. I described their appearances, determined their magnitudes, and explained the laws which governed their motion. But political conditions on this planet have disturbed my power to concentrate on the universe, so I am stopping at the Southern Cross, where I teach the Geography of the Heavens, and Methods of Tracing the Stars.

Judge—Sit down. Next juror.

Officer—Enter Spherical Trigonometry.

(*Enter Spherical Trigonometry.*)

Judge—What do you do?

Spherical Trigonometry—I am general assistant in the firm of Practical and Nautical Astronomy.

Judge—Sit among the jury. Next.

Officer—(*Shouts.*) Next!

Judge—Who are you?

Analytics—Your Honor, to be frank, I am appearing under an assumed name. I came into the world as Geometry, but in my youth I came under the dominion of Algebra. Her influence was

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a good one. I grew in strength and finally reached such a state of independence that we considered it wise to assume a new name, Analytics, that my present status might be recognized. I am both *plane* and *solid.*

Judge—Sit among the jurors.

Officer—The jury is all here, your Honor.

Judge—(*Raps.*) Order in the court. The jury is sworn to render a verdict according to the evidence. Do you swear?

Jury—(*Shaking heads.*) Not aloud.

Judge—We are now ready for the trial.

First Lawyer—I represent the plaintiff.

Second Lawyer—And I appear for the defendant.

Judge—Call the plaintiff.

Officer—Let the plaintiff, B, enter.

(*Lead B and his friend D in to witness side of room.*)

Second Lawyer—Your Honor, my client is ready to proceed when you are.

Judge—Bring in A.

Officer—Bring in the defendant. (*Conduct A to chair on jury side of room.*)

Judge—Is this jury satisfactory?

First Lawyer—(*Confers with his client.*) It is to our side.

Second Lawyer—(*Same business.*) And satisfactory to us.

Judge—(*To jury.*) Gentlemen of the jury, you will render a verdict in the case of B versus A, the defendant, whom he charges with the death of C, their partner, and sues for a share of A's profits in accordance with the law of Arithmetical Progression.

First Lawyer—May it please your Honor, and gentlemen and ladies of the jury, I present my case to you. The men involved are not unknown to you. You have followed their history through countless pages of problems. It is a long time since you were told, "A, B, and C can do a certain piece of work. A can do as much in one hour as B in two, or C in four. Find how long they work at it." Or thus, "A, B, and C are employed to dig a ditch. A can dig as much in one hour as B can dig in two, and B can dig twice as fast as C. Find how long, etc., etc." Or after this wise, "A lays a wager that he can walk faster than B or C. A can walk half as fast again as B, and C is only an indifferent walker. Find how far, and so forth."

The occupations of these men are many and varied. In the older arithmetics, they contented themselves with doing a

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"certain piece of work." This statement of the case, however, was found too sly and mysterious, or possibly lacking in romantic charm. It became the fashion to define the job more clearly and they set themselves at walking matches, ditch-digging, regattas, and piling cord wood. At times they became commercial and entered into partnership, having with their old mystery a "certain" capital. Above all they reveled in motion. A rides on horseback, or borrows a bicycle and competes with his weaker associates on foot. They have raced on locomotives, they have rowed, or again they have become historical and engaged stage-coaches, or at times become aquatic and swam. If their occupation was actual work, they preferred to pump water into cisterns, two of which leak through holes in the bottom and one of which is water-tight. A, of course, had the good one. He always took the bicycle and the best locomotive, and the right of swimming with the current.

Whatever they did, they put money on it, being all three sports. And A always won.

You will notice A is a blustering fellow, hot-headed and strong-willed. It was he who proposed everything, challenged B to work, made the bets, and bent the others to his will. He is a man of great physical strength and phenomenal endurance. He has been known to walk forty-eight hours at a stretch and to pump ninety-six. He has bullied B and C, kept them in his power, having won all their money in bets. He enslaved them and ruined their health. He finally exterminated C with his endless betting and gambling. He drove the others, whose spirits were willing but whose flesh was weak.

May the law of Arithmetical Progression descend upon his head!

Let B, the plaintiff, take the stand.

B—Oh, dear, don't let him (*Gestures to A.*) start me piling up those papers or (*Hesitates.*) measuring the density of their heads. (*Reassured by lawyer, goes to stand.*)

Judge—The evidence you will give in this case will be the truth, or as much of it as you can tell?

B—(*furtive glance at A.*) Yes, your Honor.

Judge—What is your name?

B—B, sir.

Judge—Are you married?

B—Not now, sir. She died of worry, sir.

Judge—What is your age?

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B—As well as I can remember, we were invented by some mathematicians, 1000 B. C.

First Lawyer—(*Encouragingly.*) Tell your simple story of wrong and suffering to the jury. Tell them how you and C were inflicted by the heartless wretch seated there.

B—I'll try—but—I have no heart for work and he is sure to start something. (*Looks on the verge of tears.*)

A—(*To second lawyer.*) I bet if he begins to cry, I can make twice as much noise as he can.

First Lawyer—(*Jumps up.*) Listen to him, your Honor, the gambler is betting again. After he has wheedled all he could from my client and the deceased C, including the life of the latter, he turns to the prolific source at his side. (*To B.*) Go on with your story.

B—It all began, that is, the end began one evening after a regatta. We had been rowing in it and it transpired that A could row as much in one hour as I could in two, or C in four. C and I came in fagged out and C was coughing badly. "Never mind, old fellow," I said to him. "I'll fix you up on the sofa and get you some hot tea." But A came blustering in and said, "I say, you fellows, Hamlin Smith has shown me three cisterns in his garden and said we can pump till tomorrow night. I bet I can beat you both. Come on. You can pump in your rowing things, you know. Your cistern leaks a little, I think, C." I said it was a shame, that C was used up now, but we went, and—(*Sigh.*) soon anyone could tell from the sound of the water that A was pumping four times as fast as C.

We never got any time to eat or sleep, and soon we couldn't keep at our accustomed tasks. Work in that line is now done by M, N, and O, and some people are now employing for algebraical jobs four foreigners called Alpha, Beta, Gamma, and Delta.

Poor C was an undersized, frail thing with a plaintive face. Constant walking, digging, and pumping had broken his health and ruined his nervous system. His joyless life had driven him to smoke more than was good for him. And his hand often shook as he dug ditches. He had not the strength to work as A and I did; in fact, as Hamlin Smith said, "A could do more work in one hour than C in four." But he wouldn't listen to me. But I can't go on (*Sob.*), it was all too heartless. (*Jury and officer all start into tears and sobs.*)

First Lawyer—Your Honor, and gentlemen and ladies of the

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jury! This is the most heartless case of overwork within school doors that it has ever been my fate to hear of or be interested in. There is no money on earth or no punishment that can heal my client's bruised heart or atone for his loss in the person of little C for whom he always had a gentle, brotherly feeling. We seek some balm for this shattered heart—the arithmetical sum of a series of 500 terms beginning with 3 when the difference is 7—a mere bagatelle. That will not return one-half of my client's lost manhood and assertiveness. Yet we will take it—take it as a lesson to future mathematicians (*Gestures to audience.*) tempted to overwork those in their power. I ask you to shed tears for my client if you have any to shed. If you have none, think of the deceased. He (*Indicates B.*) has told you the solemn truth in all its harrowing details. To further substantiate the truth spoken by him, I call to the witness stand D, at one time affiliated in this partnership. (*D comes to stand.*) He will corroborate all the details so reluctantly given by B, my client.

(*Court clerk takes big book to D at the witness stand.*)

Clerk—Do you swear to tell the truth, the whole truth, and nothing but the truth?

D—Yes, sir.

Clerk—Put your hand on the book and say, "I do so swear."

D—(*Very awed, places hand on book.*) I do so swear.

(*Clerk returns to take notes.*)

Judge—What is your occupation?

D—I just scratch about in the garden, sir, and grow a bit of logarithm or raise a common denominator or two. But Mr. Euclid he use me still for them propositions, he do.

Judge—Do you realize the nature of an oath?

D—I've heard my father use them. . . .

Second Lawyer—(*Arises.*) Your Honor, and gentlemen and ladies of the jury. I represent the much-maligned person A, alias John of "John, William, and Henry," alias x of "x, y, and z," my client. First I will cross-examine the witness. Do you know the defendant?

D—Do I know 'em, sir? Why, I knowed 'em all ever since they was little fellows in brackets. Master A, he were a fine lad, sir. Though I always said, "Give me Master B for kind-heartedness like." Many's the job as we've been on together, sir. Though I never did no racing or aught of that, but just the plain labor, as you might say.

Second Lawyer—(*quickly, with an aim at bewildering D.*)

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Do you know any of the details leading up to this most infamous attempt at blackmail, coercion, and vilification?

D—(*Not comprehending.*) N-n-no, sir.

Second Lawyer—Has the plaintiff ever told you of the prospects he would have in case he sued said defendant in this court of appellate jurisprudence and legal acumen?

D—(*Still not understanding.*) N-n-no, sir.

Second Lawyer—Did you behold said manslaughter coming under the head of fatigé corpus, Sec. 2, pg. 45, state laws of jurisprudence, Littleton or Coke?

D—N-n-no, sir.

Second Lawyer—Nor would the actual occurrence, having taken place homicidal or technical, with malice or forethought, create a desire for his perpetual incarceration?

D—No, sir.

Second Lawyer—Your Honor, their star witness is on the stand. (*Mimic.*) Yes, sir; no, sir; no, sir. Gentlemen and ladies of the jury, is this evidence in a court of law? A child could have fathomed my legal phrases and meaning. (*To D.*) Did you comprehend the significance of my interpellations

D—(*With the same bewildered look.*) N-n-no, sir.

Second Lawyer—Do you speak French?

D—No, sir.

Second Lawyer—Do you speak German?

D—No, sir.

Second Lawyer—Do you speak Spanish?

D—No sir.

Second Lawyer—Do you speak Italian?

D—No, sir.

Second Lawyer—Do you speak Hindoo?

D—No, sir.

Second Lawyer—(*To jury.*) You will observe that I have addressed him in seven different languages and he can't understand one. (*To D.*) That is all. You may come down.

First Lawyer—(*Interrupts.*) Your Honor, I would like to question this witness.

Judge—Let this proof be brief and to the point.

First Lawyer—Were you not present at the melancholy end of your former acquaintance, C?

D—(*Face clearing up as he understands.*) Yes sir.

First Lawyer—Tell what you know.

D—Well, sir, A and B had been rowing on the river for a wager

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and C had been running on the bank and then sat in a draught. Of course the bank refused the draught and C was taken ill. A and B came home.

First Lawyer—(*Interrupts.*) And found C lying helpless in bed?

D—Yes, sir.

First Lawyer—(*Questioning.*) A shook him roughly and said, "Get up, C, we are going to pile wood." C looked so worn and pitiful that B said, "Look here, A, I won't stand this. He isn't fit to pile wood tonight." Is this so?

D—Yes, sir, and C smiled weak like and said, "Perhaps I could pile a little if I sat up in bed."

First Lawyer—(*As a question.*) Then B, thoroughly alarmed, said, "See here, A, I'm going to fetch a doctor; he's dying"?

D—(*Humbly.*) Yes, sir, and A got mad, sir, and said they had no money to fetch a doctor.

First Lawyer—What did B do then?

D—He said, "I'll get a doctor. I'll reduce him to his lowest terms. That will fetch him."

First Lawyer—Yes, and then?

D—Well, sir, C's life might have been saved even then if it hadn't been for a mistake about the medicine. It stood at the head of the bed on a bracket, and the nurse accidentally removed it from the bracket without changing the sign.

After that blunder C sank rapidly. On the evening of the next day (*Melancholy.*) as the shadows deepened in the little room, it was clear to all that the end was near. I think even A was affected at the last as he stood with bowed head aimlessly offering to bet with the doctor on C's labored breathing. "A," whispered C, "I think I'm going fast." "How fast do you think you'll go, old man?" murmured A. "I don't know," said C, "but I'm going at any rate."

The end came soon after that. As his soul sped heavenward, A watched its flight with melancholy admiration, and B (*Sniffling.*) burst into a flood of tears. (*Sobs.*) We put away his little cistern and the rowing togs he used to wear and we, B and I, sir, we feel as if we could hardly ever dig again. (*Crying—deep sob.*)

(*Judge raps for order.*)

First Lawyer—That will do. Calm yourself. You may come down.

Second Lawyer—(*Jumping up.*) Oh, your Honor, and—I

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came near forgetting—ladies and gentlemen of the jury, I want you to look in the face of my client. His life has been arduous and full of peril. A mistake in the working of a sum might keep him digging a fortnight without sleep. A repeating decimal in the answer might kill him, yet he was not deterred. He went right on betting and supplying arithmetics and algebras with page after page of problems. Now you will have a chance of showing your gratitude. Is he to be held accountable if C's strength was in inverse proportion to his own? Because he is a full-blooded, energetic fellow with much initiative, do you think he is without a heart, without emotions? Ah, you forget his panting sides as he pumped water four times as fast as C. You forget his eager counting of the last exhalations of the dying C. Did he not admit himself baffled by the rate and direction of the flight of C's soul? I have here a vector diagram of that same occurrence which he constantly carries with him to have for reference when his own soul flees. He is still confident that his soul will overtake C's before the former comes to rest. Did he not attend that little funeral so plain and unostentatious? Is this acting as a murderer? No! (*Ringing tone.*) but as a true sporting man and mathematician he engaged two hearses, one for himself and one for B. Both vehicles started at the same time, B driving the one which bore the sable parallelepiped containing the last remains of his ill-fated friend. A, on the box of the empty hearse, generously consented to a handicap of 100 yards, but arrived first at the cemetery by driving four times as fast as B.

As the sarcophagus was lowered, the grave was surrounded by the broken figures of the first book of Euclid.

It may be noticed that A has become a changed man, has lost interest in racing, and digs but languidly. He has given up work and settled down to live on the interest of his bets. Oh, your Honor, and ladies and gentlemen of the jury, look at my client. The learned legal brother is trying to get the sum of an arithmetical series from him as balm. Oh, again I say to you, this is a base conspiracy, and I rely on your sound judgment, and I feel sure that conspirators and blackmailers will fail in their attempt to extort money from my client. I am attending to that myself. (*Sits down and fans himself.*)

Judge—Gentlemen and ladies of the jury. You have heard the evidence on both sides. If you have a verdict for the plaintiff, let it be balm enough to revive his interest in mathematics.

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If you find a verdict of acquittal on the charge of murder and extortion for the defendant, so let it be known.

(*Silence in the court while the jury confers.*)

(*Jury files out of the room—in a very short time files back again, Chairman first. B weeps and A begins to bet with his lawyer on the length of time it will take the jury, etc. When jury is seated judge raps for order.*)

Chairman of the jury—(*Arises.*) We have agreed upon a verdict—that is, I have, and the rest have come down to the same terms.

Judge—What is your verdict?

Chairman of the jury—Guilty, your Honor, in the nth degree.

Judge—In the eyes of the court, the problem through the proper reduction of radicals involves the personal equation such that $A = B+C$. C approaches infinity, through no fault of his own, leaving A and B to settle. B, in his charge of murder and extortion, has proved his claim, and A by his own *demonstration* has proved his intellectual quantities imaginary. Treat them both simultaneously. If A finishes before B, who will drink only half as fast, he will devote the rest of his term to determining the value of π, especially Omega and Nu π. The result is to be sent to Mr. Hoover and the Housewives' League.

(*Exit judge, then jury, then the rest.*)

A GRAPHICAL REPRESENTATION OF APPROXIMATIONS FOR SQUARE ROOT.

By Otto Dunkel,

Washington University, St. Louis, Mo.

In the January, 1918, number of School Science and Mathematics a simple rule was given for approximations to any root of a number, and it was pointed out how any degree of accuracy could be obtained by successive applications of the rule. In this article it will be shown how the process can be represented graphically in the case of square root in a manner which exhibits the rapidity of convergence of the successive approximations and which also yields a test of the accuracy of each step. In the article referred to there is an inaccurate statement of the rough estimate of the number of decimals which could be depended upon, and this inaccuracy will be corrected below. It will also be shown algebraically how the method can be supplemented by certain corrections which yield additional correct figures.

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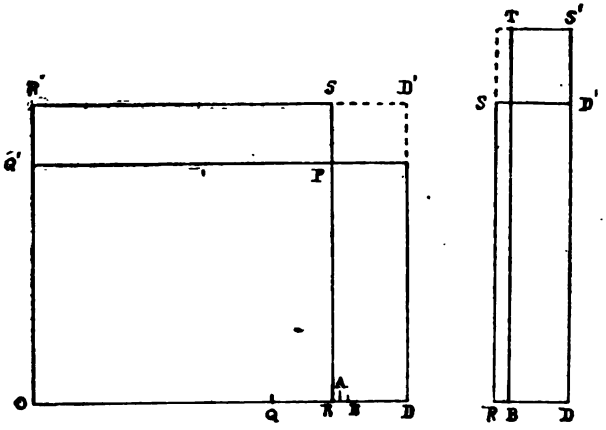
If we suppose that r is the square root of the given number, then that number can be represented by the area of a square whose side is $r = OR = OR'$ as in the figure below.

If d is the number which we first try, or one of the numbers determined as an approximation by the rule, then the next approximation is obtained by dividing the given number by d and taking the average a of the quotient q and the divisor d. We shall suppose that d is larger than q. Thus d and q give the lengths of the sides OD and OQ′, respectively, of a rectangle



having the same area as the square and such that OD is larger and OQ′ smaller than the side OR of the square. The rectangle is shown in the figure placed upon the square so that the two have the right angle at O and the overlapping rectangle OP in common. It follows at once that the area of the rectangle R′P is the same as that of the rectangle PD. Add to each of these latter rectangles the small adjoining rectangle PD′, and it will be seen that the areas of rectangles Q′D′ and SD are the same. Since R′D′ is greater than D′D, it follows that Q′R′ is less than RD, and if we lay off on DR the length DB = Q′R′, the point B will fall within DR. Mark off also on OR the length OQ = OQ′ = q. The average a of OQ and OD is given by OA where A is the mid-point of QD and also of RB since QR = BD. Hence the average a = OA is greater than r = OR. It should be observed that this is a proof that the arithmetic mean of any two positive quantities is greater than their geometric mean, for it shows that $(q+d)/2 = a > r = \sqrt{qd}$.

The error in taking a as the root is the length RA, which will be denoted by e', while the error in d is RD, denoted by e_1, and

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the error in q is QR, denoted by e_2. The figure gives a good idea of how much smaller e' is than either e_1 or e_2. Only in case of a selection of d obviously too large can e' be greater than e_2. We shall now obtain from the figure a very useful relation between e' and e_1 which enables us to test the accuracy of the approximations at each step. The figure to the right shows the rectangle RD′ with the rectangle Q′D′ placed upon it in the position BS′ so that Q′R′ coincides with DB. Since these two rectangles have equal areas the area of the thin rectangle SB is equal to that of the rectangle TD′, which is almost square, lacking only ST to be a complete square. Adding then the little rectangle ST to each of the rectangles SB and TD′ we have the final result that the rectangle RT and the square SS′ have equal areas, i. e., $RB \times BT = SD'^2$, or, since $RB = 2e'$, $BT = d$ and $SD' = e_1$,

$$(1) \qquad e' = \frac{e_1^2}{2d}, \quad \text{where } e' = a - r,\ e_1 = d - r.$$

This shows how rapidly the error decreases from one approximation to the next. For example, if d is correct in the first three decimals, then $e_1 < .001$ and hence $e' < .0000005/d$ so that a will be correct in six decimals, or more if d is much larger than 5. Thus we may state the rough rule that the correct number of decimals in any approximation is in general twice the number in the preceding approximation.

In a similar manner it may be shown from the figure that

$$(2) \qquad e' = \frac{e_2^2}{2q}, \qquad e' = \frac{e_1 e_2}{2r}, \quad \text{where } e_2 = r - q,$$

and with a little more trouble but in an analogous manner that

$$(3) \qquad a - r = e' = \frac{h^2}{4(a+r)}, \quad \text{where } h = d - q.$$

This last result may also be obtained by combining the equations in (1) and (2). Since $a > r$ and $r > q$ we deduce from (3) the inequalities

$$(4) \qquad \frac{h^2}{8a} < e' < \frac{h^2}{4(a+q)},$$

which are more convenient as tests of accuracy than the others since we always know h. To illustrate the use of these inequalities, let us approximate $\sqrt{3}$ by taking first for d the value 2; we find mentally that $q = 1.5$ and $a = 1.75$. Applying the rule again and taking now $d = 1.74$, since 1.75 is too large, we find

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that $q = 1.7241379310$ and $a = 1.7320689655$. Computing roughly the value of the expressions in (4) we find that $.00001815 < e' < .000018199+$, and, reducing a by the smaller number, we have 1.7320508 as correct figures of the root. This shows how we may use the expression to the left in (4) as a correction in order to obtain more correct figures, or, in other words, that

$$(5) \qquad a - \frac{h^2}{8a}$$

is a better approximation to r than a. It may be seen from what follows that (5) gives really more correct figures than were indicated above, in fact, we may use ten decimals of the correction .0000181579, thus obtaining as correct figures of the root 1.7320508076.

It is possible to find a second correction, a third, and so on, but it is not so easy to do this graphically, and so we shall proceed algebraically. The error in (5) is

$$a - \frac{h^2}{8a} - r = (a-r) - \frac{h^2}{8a},$$

which may be factored by replacing $(a-r)$ by its value in (3) and reduced further by the same substitution, thus

$$\frac{h^2}{4(a+r)} - \frac{h^2}{8a} = \frac{h^2(a-r)}{8a(a+r)} = \frac{h^4}{32a(a+r)^2}.$$

Hence we have

$$(6) \qquad \frac{h^4}{128a^3} < a - \frac{h^2}{8a} - r < \frac{h^4}{32a(a+q)^2}$$

The expressions on the right and left of the inequality sign do not differ greatly and hence we may use the one to the left as a second correction. We obtain in this way the still better approximation

$$(7) \qquad a - \frac{h^2}{8a} - \frac{h^4}{128a^3}.$$

By subtracting r from this expression, and factoring and reducing as before in order to find the error, we shall find a third correction and the approximation,

$$(8) \qquad a - \frac{h^2}{8a} - \frac{h^4}{128a^3} - \frac{h^6}{1024a^5}.$$

The reductions become troublesome when we proceed much further in this way, but by the use of the binomial theorem for fractional exponents all of these terms and as many more as may

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be desired may be easily obtained. For we have only to write the equation (3) in the form $r^2 = a^2 - h^2/4 = a^2(1 - h^2/4a^2)$, or $r = a(1 - h^2/4a^2)^{\frac{1}{2}}$, and expand the second factor in order to obtain the above development. This development by the binomial theorem will yield very easily any number of terms, but it depends upon the demonstration of the validity of the binomial theorem for fractional exponents, and this demonstration is quite difficult. But for any ordinary computation only one or two of the correction terms would ever be needed since they diminish very rapidly when h is small, as in the computation of $\sqrt{3}$ above, and in this case the first method of derivation has the advantage of using only simple algebraic reductions and of furnishing very convenient upper and lower limits for the error. Thus the original process of successive divisions and taking the average may be supplemented by the above explained method of subtracting from the last average found one or more corrections. However, for general use the unsupplemented method is by far preferable as a rule easily remembered and understood, and sufficiently rapid.

The simpler rule has in addition an important theoretical significance, for it gives a very simple and satisfactory definition of the square root of any positive number. Thus if N is any positive number we may define $\sqrt{N}$ in the following way: Divide N by any convenient positive number d and denote the quotient by q and the average of q and d by a_1. Now divide N by a_1 and find the corresponding quotient q_1 and average a_2. Proceeding in this way we find two endless sequences of numbers:

$$\begin{array}{ll} \text{(A)} & a_1, a_2, a_3, a_4, \ldots a_i, a_{i+1}, \ldots \\ \text{(B)} & q_1, q_2, q_3, q_4, \ldots q_i, q_{i+1}, \ldots \end{array} \quad \text{where} \begin{cases} a_{i+1} = \dfrac{a_i + q_i}{2} \\ a_i q_i = n. \end{cases}$$

such that the sequence A decreases while the sequence B increases, and the difference between a corresponding pair of terms of A and B, $a_i - q_i$, is positive and approaches zero as i increases. Also the square of any term in A is greater than N, while the square of any term in B is less than N. The sequences A and B approach therefore the same limit and this limit is $\sqrt{N}$.

These facts may be proved without assuming the existence of $\sqrt{N}$, as is desirable in such a definition. The proofs are not difficult and are left to the reader as an exercise. A similar definition may be formulated for any root of a positive number.

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TWO METHODS OF LOCATING THE GERMAN SUPER GUN.

By Harris F. Mac Neish,
College of the City of New York.

Method by Means of Circles.

Three observation stations, A, B, and C, are established near the front line, Station A being somewhat in advance of B and C. Station A is connected by wire with Stations B and C, and an instrument is set up at A so that the pushing of a button will start clocks going at B and C. When the discharge of the gun is heard at A the button is pushed, and when the discharge is heard at B and C the time is recorded by the observers.

Suppose the time recorded at B is two seconds, and at C three seconds. The velocity of sound is accurately determined in advance, but for simplicity assume the velocity to be 1,000 feet per second. It is evident then that A is 2,000 feet nearer to the gun than B, and 3,000 feet nearer than C.

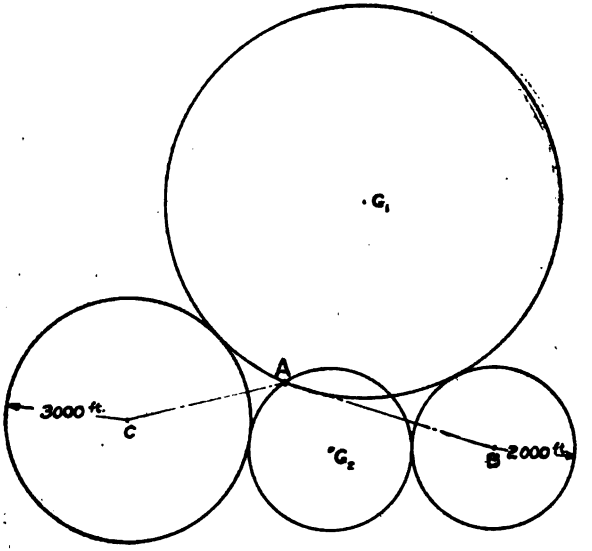

Figure 1.

A, B, and C are located accurately on a military map (see Figure 1), and two circles are drawn on the map to scale, one with B as center and 2,000 feet as radius, and the other with C as center and 3,000 feet as radius. Two circles are then drawn passing through A and tangent externally to the circles about B and C. Call the centers of these circles G_1 and G_2. G_1 and G_2 are evidently 2,000 feet farther from B than from A, and 3,000

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feet farther from C than from A, and hence one of them is the required position of the gun. In practice one of the two positions, G_1 or G_2, may be excluded by direct observation as one of the two points usually lies back of the lines. Moreover, the determination is repeated many times, based upon successive discharges of the gun, and upon different positions of the stations, and the vicinity of the gun is located accurately within certain limits.

METHOD BY MEANS OF HYPERBOLAS.

Three stations, A, B, and C, are established as before. The stations are provided with very accurate clocks which are set at exactly the same time (clocks are available measuring time accurately to one one-hundredth of a second). When the discharge of the gun is heard, the time is recorded at the three stations. Suppose that as before the velocity of sound is taken as

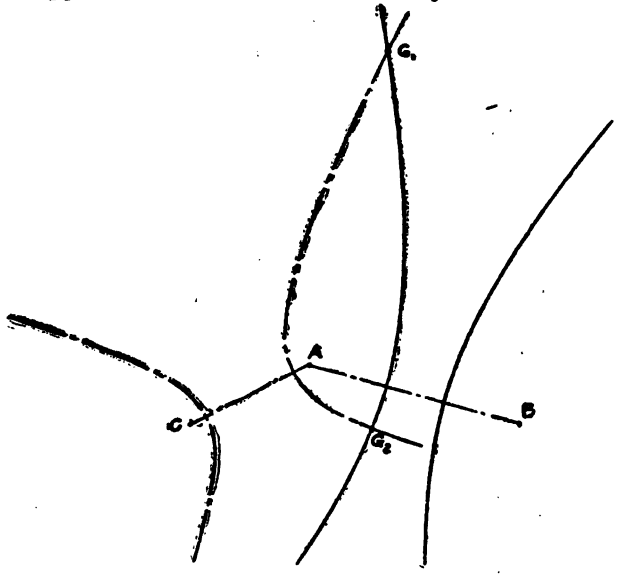

Figure 2.

1,000 feet per second and that the gun is heard at A two seconds sooner than at B and three seconds sooner than at C.

The gun is therefore 2,000 feet nearer to A than to B. The locus of all points, the difference of whose distances from A and B is 2,000 feet, is a hyperbola drawn with A and B as foci and 2,000 feet as transverse axis. The branch adjacent to A is the locus of all the points 2,000 feet nearer to A than to B.

A, B, and C are located accurately on a military map (see

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Figure 2), and the branch of the hyperbola drawn on the map to scale. The gun is situated somewhere in this curve. Similarly, a hyperbola is drawn with A and C as foci, and 3,000 feet as transverse axis. The gun will also be situated on the branch of that hyperbola adjacent to A. These two curves will intersect in two points, one of which will be the required position of the gun. In general, as before, no difficulty would be encountered in determining which of the two positions is the correct one. However, a third hyperbola may be drawn from the data with B and C as foci and 1,000 feet as transverse axis, and the gun will lie on the branch adjacent to B.

This branch will in general pass through only one of the two points previously determined, and the position of the gun will be determined uniquely.

AN APPLIED COURSE IN HIGH SCHOOL PHYSIOGRAPHY.

By O. W. Freeman,

Fergus County High School, Lewistown, Mont.

It is becoming a habit for science teachers to urge the merits of general science for high school students in preference to any particular science. Physiography especially has suffered as a result, and the subject is no longer taught in many schools. The writer admits that general science has a place in the curriculum and teaches a first-year class in the subject, but believes that physiography offers a splendid opportunity to direct the students along many practical lines. Physiography is elected by seventy-three per cent more students than general science in the Fergus County High School at Lewistown, Mont. It is popular with the upper classes, and fifty-eight per cent of those taking physiography are from the three upper classes. Thirty-seven per cent of the class have had some other science course previously. Lewistown is in an exceedingly interesting part of Montana from a geologic, physiographic, and mining standpoint, and the subject of physiography fills a real need in an institution located there. The writer has adopted the suggestions of others along with his own for an applied course in physiography, and the course as given is the result of many years of teaching the subject and is modified from year to year.

The school year at the Fergus County High School is thirty-eight weeks long, of which two weeks are used for examinations. A textbook is followed so far as general topics are concerned, but recitations on the assignments are the least part of the course.

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Lectures by the instructor are not overemphasized and are usually limited to giving examples of the topics under discussion from Montana and Fergus County in particular. No textbook in physiography can hope to be complete for any particular locality. To make a course practical or interesting it must be supplemented by local examples. A large number of lantern slides, especially on local subjects, are used for illustrative purposes. The lantern is a Baush and Lomb with reflectoscope attachment, and picture post cards and illustrations from books, magazines, etc., are freely used. Frequent reference is made to the daily press and current magazines for such topics as: Influence of weather on the war, the reasons for the success or failure of fruit and grain crops in Montana and elsewhere, and the reasons for the location of cities and new manufacturing plants. Considerable commercial geography can be thus taught, and if an illustration is timely it is used without waiting until the most closely related part of the text is reached. Constant use is made of both physical and political maps and they are particularly used to show the cause for the varying climates of the earth and the effect of climate and topography on the distribution of population and the character of man's activities, industries, and culture. It has been found that the average high school pupil is weak on locational geography and it is necessary to locate on the map many places with which a student should be familiar.

Instead of the instructor giving all the outside information to the students it has been found that they will listen better and remember more if one of their own number looks up the matter and makes a report to the class upon it. These reports are also desirable as they help the student gain in power of expression. Usually only certain parts or chapters of a book are used as a basis for reports. Among the books found useful are the following:

Bowman, *Forest Physiography;* Russell, *Lakes of North America; Rivers of North America;* and *Glaciers of North America;* Salisbury, Barrows, and Tower, *Modern Geography;* Brigham, *Geographic Influences in American History;* Mill, *International Geography;* Davis, *Geographic Essays;* Geike, *Earth Sculpture;* Bonney, *Volcanoes;* Davis, *Meteorology;* Ward, *Climate;* Merrill, *Rocks, Rock Weathering, and Soils;* Pirsson, *Rocks and Rock Minerals;* Wallace, *Island Life;* Fairbanks, *Physiography;* Salisbury, *Physiography;* and many others. Many of the publications of the U. S. Geological Survey, Weather Bureau, Smithsonian Institution, Carnegie Institution, Forest Service, Department of Agriculture, Department of the Interior, and various state departments have been used. Many technical and popular magazines have also been used.

Laboratory work and field trips take up two days out of five

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each week. No laboratory manual is used, but notebooks are kept. Some fifty different contour maps are studied in considerable detail. Montana maps are emphasized, but typical examples are chosen from all parts of the United States. Special attention is paid to the effect on man of the cycle of erosion in both an arid climate and a humid climate. In order to make the maps seem more real to the students, each is frequently asked to describe from a study of the map what would be seen by looking in a certain direction from a given hill or other landmark, and what would be the origin of the land forms seen. No useless cross-section work on topographic maps is done. Series of weather maps are studied until the influence of cyclonic and anticyclonic areas on the weather are thoroughly understood. Some models are available but are used only for demonstration. More time is spent in a study of rocks and minerals in this western community than would probably be wise in many parts of the East and Central West. The rocks are studied mainly in the field and include limestone, sandstone, shale, conglomerate, coal, gypsum, quartzite, granite, diorite, lava, volcanic tuff, and various porphyries. The minerals studied are all in Montana and most of them are in Fergus County and include: calcite, dolomite, calcareous tufa, halite, and other alkaline salts, quartz, gypsum, hematite, magnetite, limonite, pyrite, gold, galena, calaverite, argentite, spalerite, various feldspars, horblende, augite, covellite, chalcocite, bornite, chalcopyrite, azurite, malachite, sapphire, topaz, garnet, and some others. A few fossils are studied, mostly on field trips, but a considerable number are available for inspection in the museum.

The field trips are very popular with both the pupils and the instructor, and are taken nearly every week during the good weather of the autumn and spring. Short trips are taken during the regular class hour to little creeks and rock outcrops within a mile of the schoolhouse to study weathering and the origin of soils and maintenance of soil fertility, and the work of ground water, running water, and the wind. Several automobiles are donated by members of the class for use on longer trips, which enables the class to reach the nearest mountains in half an hour. The details of glacial phenomena so common in the lake states cannot be seen, as mountain glaciers and the continental ice sheet were not found near Lewistown. The subjects studied on the trips to the mountains include: igneous phenomena as dikes, laccoliths, sills, and dissected volcanoes, and erosional forms as

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box canyons, buttes, pinnacles, rock terraces, river terraces, hogbacks, waterfalls, natural bridges, arches, caves, and sinks. Structural features like anticlines, synclines, and faults can be easily seen. Gold, sapphire, coal, and gypsum mines are visited and the general methods of mineral extraction noted. Landslides, ice caves, giant springs, mineral springs, and their mineral deposits of iron and travertine have been visited and studied on the trips. On the same trip the boys have been chilled in exploring the depths of an ice-filled cave and a few minutes later warmed themselves by swimming in a giant warm spring. The class secures an appreciation of landscape and scenic features through the field trips which can never be secured in the classroom.

The field trips are made the basis of essays on the subjects studied, and if the written work is properly done theme credit in English can be secured. The essays are read in class and freely criticized, both as to the completeness and accuracy of the information and its expression in correct language. Usually we find that a combination of parts from different essays would make a better piece of work.

The writer has no apology for introducing geology, mineralogy, and geography into a course in physiography. The subjects introduced are decidedly practical and are of use to the pupil in after life and to the students who later take agriculture, physics, chemistry, history, and other subjects. The writer prefers to use a standard introductory textbook of physiography which gives the proper background, and finds it easy to introduce the applied phases of geography in the ways suggested in this paper rather than use a textbook that pretends to introduce these things in its subject matter. Such a textbook would be of unwieldly length if it actually did introduce all these applied phases and would be suitable for use in only one part of the United States then. Each region has its own problems, and the properly trained teacher can better supplement the text than to depend on an ideal text that has not been written.

THE PENOBSCOT A BRAIDED STREAM.

The Passadumkeag, Maine, typographic map just issued by the Geological Survey, Department of the Interior, shows that the Penobscot River between Old Town and West Enfield, Maine, is a striking example of a braided stream. The river here has but slight fall and therefore cannot carry away all the sediment that is swept into it by its numerous tributaries, and this material chokes the stream and forces it to spread into many shallow and shifting channels, the pattern formed resembling the strands of a braid.

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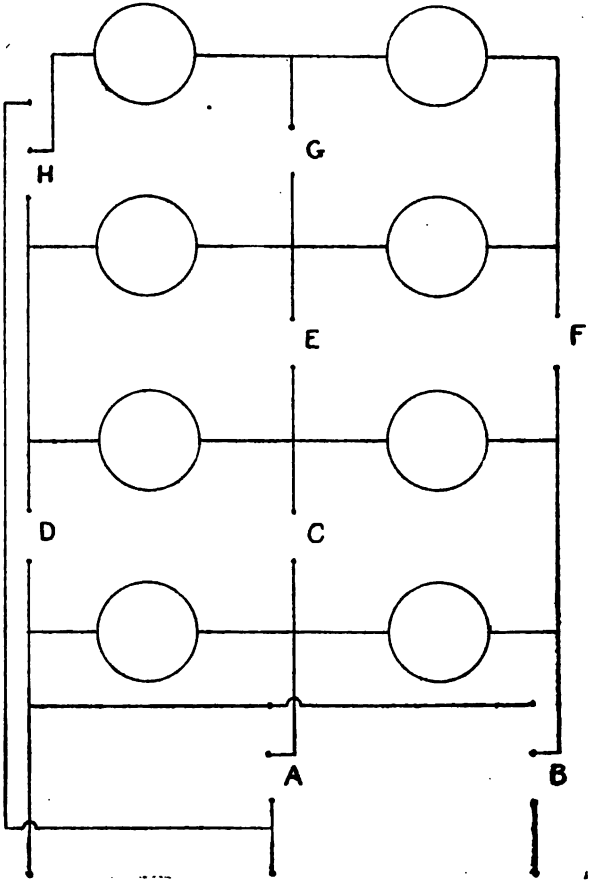
A CONVENIENT LAMP BANK.

By P. C. Hyde,

Newark Academy, Newark, N. J.

The lamp bank, of which a diagram is here shown, was devised to combine as many utilities as possible in a single piece of apparatus that should be at once simple and safe. It is used as a demonstration and laboratory piece, and as a lamp rheostat.

As appears from the diagram, there are eight lamps and eight switches, all of the latter single pole, three double throw and five single. The board is wired in front, and built large enough so that the lamps do not hide the wiring when the apparatus is hung against the wall of the lecture room. The position of the switches, open ones showing white on a white background, makes it easy for pupils to trace the path of the current at each



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stage of a demonstration or experiment. For added distinctness the copper switch blades are painted black to correspond with the wiring.

The binding posts are connected to a three-wire current supply, direct or alternating. For lamps in parallel A is down (towards the binding post), H likewise, B is up, and the other switches are closed. Single lamps are extinguished by opening in succession H, G, F, E, D, C, and B. With A, B, and H all down and the other switches all closed, the lamps are connected on the three-wire system; the effect of blowing a neutral fuse, and the necessity of the neutral wire to keep the voltage even when the sides are unbalanced, is shown by opening A, which puts the lamps in multiple on 220 volts. By connecting an ammeter, preferably zero centered or alternating current, in the neutral line, the value of the current in the middle wire for unbalanced three-wire operation is clearly shown. With an ammeter in each line, the neutral current is shown to be the difference of the other two, a fact essential to the economy of the system.

With H up and the other switches open the lamps are in series, and individual lamps are cut out by closing in succession A, B, (both up), C, D, E, F, and G. The increasing current can be shown clearly by the changing glow of a 15-watt tungsten lamp adjacent to H if the other lamps are 16 c.p. carbons, as the total resistance of the latter is not sufficient to dim entirely the small lamp.

A careful examination of the diagram will show that no possible combination of switches will short-circuit either line. The only combination to be avoided is A up and B down, as this throws 220 volts across a single lamp or row of lamps. With C open and an old lamp adjacent to B it is not a bad plan to try this combination before a class, to show the need of care in testing out live wires with an incandescent lamp where there are voltages above 125, and the danger of operating unbalanced circuits in multiple.

The bank is neither difficult nor expensive to construct. The switches are of the ordinary 125 volt 15 ampere baby knife type, and the binding posts should have composition caps for protection against shock. The wiring is 14 double braid. The apparatus has proved itself decidedly convenient and instructive, and fool-proof when operated by students on a 110-volt line. Its versatility can be fully appreciated only after considerable use.

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THE RELATION OF RÖMER AND FAHRENHEIT TO THE THERMOMETER.

TRANSLATED BY WILLARD J. FISHER,

Worcester, Mass.

(Ole, or Olaf, or Olaus, Römer was born at Aarhus, Denmark, September 25, 1644; died at Copenhagen, September 19, 1710. In 1662, he became pupil and amanuensis of E. Bartholin, in Copenhagen, who employed him in classifying the manuscripts of Tycho Brahe. In 1671, he helped J. Picard redetermine the geographical position of Tycho's observatory, Uraniborg. In 1671 or 1672, he went with Picard to Paris; there he became mathematical tutor of the Dauphin and member of the Academy of Sciences, and was occupied with observations in the royal observatory and the king's hydraulic works at Versailles and Marly. In 1674, probably before Desargues and La Hire, he invented the epicycloid and indicated its applications to gear teeth. September 22, 1675, he read his paper on the velocity of light as deduced from observations of the eclipses of Jupiter's first satellite. About the same time he was interested in the design and construction of planetaria. In 1681, he returned to Copenhagen, as royal mathematician and professor of astronomy in the university. He also became mayor, chief of police and privy councilor. On his advice, Denmark adopted the Gregorian calendar.

He invented the transit and prime vertical instruments and the meridian circle, and used altazimuth circles and the equatorial mounting for telescopes. His realization of the importance of clock rate in meridian work led to an interest in expansion and contraction and a fundamental improvement in thermometers, as shown below. His observations and papers perished in the Copenhagen fire of 1728, with the exception of three night's work, preserved by Horrebow, 1735, and discussed by Galle, 1845, the *Adversaria*, mentioned below, and, of course, a few published in the proceedings of the Berlin and Paris academies. At the time of his death he was engaged in attempts to discover stellar parallax, which would inevitably have led him to the discovery of aberration, for reduction of his work has shown it to be of almost modern precision.

Accessible works are, R. Grant, *Hist. of Phys. Astr.*, p. 461; Doberck, *Nature*, 17, p. 105, 1877-78; See, *Pop. Astron.*, No. 105, May, 1903. A portrait of Römer is to be found in LaCour and Appel, Vol. I.

I find slight discrepancies among the various reference works as to dates and facts of Römer's life; Doberck's article is very full.

Kirstine Meyer, née Bjerrum, has written in Danish a book on *The Development of the Temperature Concept in the Course of the Ages*, published, 1913, in the series, *Die Wissenschaft*. Her account of Römer's part in the development of the thermometer is here translated from this German edition. It appeared first in *Archiv für die Geschichte der Naturwissenschaften und der Technik*, 2, p. 323-349, 1910.—W. J. F.)

From occasional expressions in the scientific literature of the eighteenth century, on which I came accidentally, I inferred that probably Ole Römer had busied himself with the construction of thermometers, and that there had been a relation between him and Fahrenheit. I will later come back to these expressions. They led me to search in the libraries and archives at Copenhagen for works by Römer, and only at last in the University Library; for I had to assume that the papers of Römer in possession of this library had been destroyed by the conflagration of 1728. Yet there I found what I sought, namely, Römer's *Adversaria*, in manuscript, in a volume of miscellanies.[1]

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A note on the last page tells how the book came into the possession of the library, and that it escaped the fire through being then in the possession of Römer's widow, remarried to Th. Bartholin. She gave it to the library in 1739. This note says:

"Da mein erster Gatte Olaus Römer Sel. diese cahiers in Pergament hat heften lassen, möchte ich annehmen, dass er sie selbst als von einiger Importance erachtete, weshalb ich dieses Volumen in der Bibliotheca Academica geborgen wissen möchte unter anderen Manuscripten, damit jemand darin, wie zu vermuten, etwas Nützliches darin finden könnte. E. M. Bartholin, Witwe von Th. Bartholin Sel., in octobre 1739."

This book contains a whole section on the thermometer and, besides, a few isolated remarks on temperature measurement. Römer's form of the thermometer seems to me to be of great interest; he is apparently the first to construct the thermometer with two fixed points, namely, the temperatures of melting snow (nix sine gelu et calore) and the boiling point of water, and with a division of the tube into equal volumes.[2] This happened in 1702, partly according to Römer's own notes, partly according to Horrebow's. In *Adversaria*, p. 131 b., there is a reference to Amonton's comparison[3] between his own and Newton's[4] statements of equal temperatures; Römer makes a brief extract from the comparison tables, and adds:

"The observation of the incipient freezing and of the boiling of water seems to me in the highest degree adapted for application in the construction and graduation of a universal thermometer, as the former point is sufficiently well fixed, and the latter, contrary to my earlier view, deserves confidence; for, according to the concurrent observations and reliable assurances of the French, boiling water, once the boiling has begun, cannot increase its temperature."

In 1703, then, Römer seems to have been clear about the principle. Horrebow has made marginal notes at various places in the *Adversaria*, from which it appears that Römer made his thermometers about 1702. He writes,[5]

[1]This *Adversaria*, written mostly in Latin, has been published by the Royal Danish Scientific Society on the occasion of the two-hundredth anniversary of Romer's death, under the editorship of cand. mag. Thyra Eibe and Dr. phil. Kirstine Meyer.

[2]On this see translator's note at end.

[3]Mem. de l'Academie Roy. des Sciences, 1703, p. 100.

[4]Roy. Soc. Phil. Trans., 22, p. 824, 1700-1701. On this scale the ice point is zero, body heat 12, water boiling violently 34; this makes body heat 35.3 C.; cf. 36.9, actual mean. I do not know that Newton ever attempted to construct a thermometer giving these readings, and I think the original shows that he did not consider the boiling point of water a constant, in spite of the observations of Halley and others.—W. J. F.

[5]*Adversaria*, p. 118 b.

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"1741, on April 10, I asked Römer's widow when he had made the five thermometers.[6] She answered, they had been made in her presence; she could not, however, recollect any contemporaneous event, through which the date could be determined; but at that time Römer could not get out, owing to a broken leg. Consequently it was before 1703, the year in which, in June, I came to Römer's observatory, for Rumohr, John and other assistants were telling that he had been dangerously ill with wound fever after a broken leg.

"On 17 April, Römer's widow came to me and said, now she knew certainly that these thermometers had been made in 1702."

The section of the *Adversaria* which deals with thermometers, etc., consists of eleven folio pages. The first heading runs, "On the calibration of glass tubes for thermometers." A solution is given of the problem, so to divide thermometers with various sized bulbs and bores, that the divisions shall agree; i. e., so that the volume of ten divisions shall everywhere have the same ratio to the volume of the bulb. He finds the diameter of the tube by means of a quicksilver drop; this he puts into the tube and measures its length, then he weighs it and calculates its volume, assuming that a cubic foot of quicksilver weighs 837 pounds. From this we see that he takes the specific gravity of quicksilver 13.5, as in the system of measures used by him a cubic foot of water weighs 62 pounds.

After he has determined the length and volume of the drop, he calculates its diameter, and so the diameter of the tube, at the region where the drop lies. That Römer is interested in this connection with the problem probably depends on this: that on several sides, as, e. g., by R. Hooke, it had been proposed to make mutually agreeing thermometers on the following principle: one fixed point, and a division of the tube into equal volumes, which should in all thermometers be in the same ratio to the bulb volume.

After solving this problem he gives a suitable formula, and adds that this really has nothing to do with his investigations, which were for determining the irregularities of the tube bores, usually conical or of irregular form.

"I investigate their form by means of a quicksilver drop before the bulb is blown on. In the tube previously mentioned I have found a sufficiently regular part, so that at the middle a

[6] It had previously been mentioned that Horrebow had used these.

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drop of quicksilver had length 7 1-2, at the wide end 8, at the narrow end 7 (arbitrary units). Between these points there were ten inches. We can consider this space a truncated cone. In this, unequal thermometer graduations must be made; i. e., longer toward the narrow end, shorter toward the wider cross-section."

The following pages deal generally with the division of conical spaces into equal volumes. Römer develops for this the necessary formulas, and explains them with numerical examples. So he finds a method suitable for dividing a conical tube into equal volumes. Then he passes to his principal problem, for whose sake the preceding developments were entered on, "To construct an original (standard) thermometer."

1. With a quicksilver drop it is found whether the tube is of regular internal form, cylindrical or conical, and, indeed, before the bulb is blown on. Irregular forms are thrown away, cylindrical are used without more ado. With conical ones we have to deal thus:

2. From the middle toward the ends we determine the lengths of quicksilver drops.

3. When the tube is thus divided into two equal parts, then each of these is again divided into two equal parts, so that we now have four equal parts.

4. When the thermometer is completed, filled and sealed, we fix with snow or pounded ice the point 7 1-2, and by boiling, the point 60.

After this are notes, written and signed by Horrebow:

"The distance from the limit of the snow to boiling (melting point to boiling point) Römer divides into seven equal parts, of which the one below the snow limit serves him for observations of greater cold. When he afterward noted that the thermometer sank below zero, he began to number downwards, from zero on with the sign $-$.

"1739, Römer's widow sent me five glasses for thermometers, which Römer himself had filled according to his rules described above, and had marked with two points. The spirits of wine in them is pretty pale, although Römer had colored it in the usual way. I asked Römer's widow if she knew whether Römer, after I left his observatories, had made any changes in his thermometer. She said that she did not know, but gave me Römer's 'Vade Mecum', in which I found a loose leaf, that is here pasted in after the next leaf. On this sheet I see that Römer had put in the graduation mark for snow; now, insofar as we know, the spirits of wine never sink below zero in Copenhagen, and it is noted that on 7 January, 1709, the spirits sank only to 7 9-10."

This loose sheet mentioned by Horrebow contains a table for

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the daily temperatures from 26 December, 1708, to 1 April, 1709.[7]

(Here follow a description and a partial figure of Römer's graphical record of temperature, one of the earliest temperature records which can be translated into modern scales with approximate accuracy. For these I make reference to the original. —W. J. F.)

Certain places in the *Adversaria* lead one to suspect that Römer had considered dividing the tube into equal lengths and making for each thermometer a table of the deviations shown between the readings of such a thermometer and one divided in equal volumes.

To sum up: We arrive at the conclusion mentioned above, the thermometer graduation rests on two fixed points, the melting point of snow, usually called the "freezing point," and the boiling point of water, and then on the determination of degree lengths by division of the tube between the two fixed points into equal volumes, in doing which account is taken of the cylindrical or other form of the tube. The size of a degree is such that between freezing and boiling points there are 52 1-2 degrees of equal volume. If the tube is cylindrical, this distance is divided into 52 1-2 equal lengths, and 7 1-2 such are marked off below the freezing point, giving the zero point; if the tube is not cylindrical, but conical, the graduation from freezing point to boiling point is carried out according to Römer's previously given method for the graduation of conical tubes; the zero point is so located that the volume from zero to freezing point is 1-7 of that from freezing point to boiling point.

Römer's thermometers were still in existence up to 1748,[8] for in his *Elementa Philosophiae Naturalis*, p. 144, Horrebow says that he had got from Römer's widow, who still owned them, five thermometers. In the *Adversaria* Horrebow tells further that he had tested them, and remarks,

"At the beginning of April, 1741, I separated from their scales five Römer thermometers, and tested them in snow and boiling

[7] This winter is famous on account of its severity. According to Romer, uninterrupted frost reigned during the period covered. But in spite of the lowest temperature, which happened twice, being only 0° (Romer) = —14.3° C., the winter got its reputation for severity through the long duration of the frost. In the *Theatrum Daniae* of Pontoppidan, he says of the winter of 1709, "It was in these and neighboring countries an extraordinarily hard winter. In the woods much game froze to death and many trees died; indeed, we heard of many travelers who froze on the way. On the Baltic (Ostsee) even in the month of May sleds traveled as on highways."

[8] *Nordisk Universitets Tidskrift*, 1859, p. 3, contains an essay on Romer by E. Phillipsen; in a note, p. 52, it is said: "Of his various instruments and machines there exist now, beside the remains of a barometer and a thermometer of his own make, which belong to the collection preserved in the former Art Museum . . . . . " The objects mentioned I have not found listed in the catalog of 1848. Neither in Schloss Rosenborg, nor in the National Museum, whither the objects of the Art Museum were taken, was there any trace of them to be found.

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water, and found after so many years exactly the same readings that Römer himself had marked with a flint."

When one sees that Römer had spent comparatively much of his closely occupied time in the construction of an "original" thermometer, there suggest themselves three questions: (1) Is this interest connected with Römer's other scientific and practical labors? (2) Did he use the thermometers so constructed for systematic measurements? (3) Did his new ideas influence others in the construction of thermometers? I will attempt an answer to these questions.

From the *Adversaria* we can conclude that the first question is to be answered, *Yes*. For two reasons: Römer wished to determine the expansion of metals by heat, partly to determine the variations with temperature of the size of a degree in an instrument in his "Observatorium Domesticum," partly to determine the temperature variation in the periodic time of a pendulum. The latter may have interested him partly on account of his astronomical observations, partly on account of his endeavors to found a system of units. Without doubt, he, in common with Picard, was planning for the introduction of a *normal foot*, in order to express in terms of it the customary length-units of different countries, and for that purpose he wished to make use of the length of the seconds pendulum. Römer and Picard assumed that this was the same everywhere on the earth.[9] Measurements by Picard, in Paris, and, with Römer's help, at Uraniborg, and by Römer himself at London, had in fact given the same value.

According to p. 67 of the *Adversaria* Römer had occupied himself with the expansion of various metals. It reads:

"Changes in length of metals by cold and heat, tried 12 December, 1692, three or four times."

Römer's measurements—whose method he unfortunately does not describe—showed that the lengths of three-foot rods of various metals, which he had divided into 6,800 equal parts, increased differently for equal warming. If his thermometer read 6 1-2 in the cold and 30 1-2 when heated, or rose 24, then the 6,800 parts increased:

For gold and copper	5 parts
For silver and tin	6 1-2 parts
For lead	9 1-2 parts
For iron (at most)	3 1-2 parts
For glass, a round tube of 1-2 inch diameter	3 1-2 parts

[9] I find this hard to understand, as Romer, 1672-3, was one of the observers who worked at Paris simultaneously with Richer at Cayenne for determining the solar parallax by observations on Mars, etc.; he could, therefore, hardly have been ignorant of the way Richer's clock varied with the latitude, when the clock was set up at Paris and at Cayenne, nor of the controversy that ensued.—W. J. F.

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so that a fiber of lead increased about 1-10 inch, of gold or copper about 1-2 inch, of tin or silver 1-15 inch, of iron and glass 1-3 inch.

"Now my instrumentum domesticum[10] can easily be kept between the cold 6 and the warmth 16, which consequently corresponds to a difference of at most eight parts on the thermometer; or, better, between eight graduations, which is a third of that observed.

"Later I added this; a higher temperature can be avoided; but cold can depress the fluid to graduation 4 near the window, where the instrument is, as I have just observed. A difference in cold and warmth of 11 and 12 is therefore to be expected; i. e., half as much as I observed in case of the rods."

The instrument here mentioned, Römer's famous meridian instrument, is figured in Horrebow's *Basis Astronomiae*. In the picture we see beside the telescope of the meridian instrument a clock, serving for the necessary determination of time. Probably Römer calculated the changes in rate of this instrument due to temperature changes. The fact is, that the iron pendulum rod altered in length 1-100 line for each thermometer degree, but a change in length of 1 line increases or decreases the rate 1 second in 24 hours.

Further, an apparatus is sketched[11] for making comparative measurements of the expansion of air and liquids by heat. It consists of a glass bulb, 1 1-2 inches in diameter, with a narrow neck, of which a length 16 1-3 inches is equal in volume to 1-22 of the bulb. Were the tube filled with water at 8° to *a*, then on heating 10° the water expanded to *b*, a point 1 3-4 inches distant from *a*, so that the expansion amounted to 1-200 of the original volume; were the bulb filled with air, inclosed by a drop at *a*, the air expanded on heating 3° to *c*, 12 inches from *a*, and on heating 10°, and with a sufficiently long tube, would have expanded 40 inches along the tube, or 1-9 of the original volume.

The increase in volume of air on 10° heating is consequently 22 times as great as that of water. Römer adds, that he had previously got the number 24; however, the later experiments were better. According as we assume that the 8° of Römer correspond to 0° C. or 15° C., we get a poor or a good agreement with modern measurements.

[10]The "Observatorium Domesticum" was founded 1689-90. It is described in Horrebow's *Operum mathematico-physicorum*, Tom. III, p. 47. (Figures of Romer's instrumentum domesticum, etc., are found in H. H. Kritsinger, *Die Errungenschaften der Astronomie*, p. 69, Weimar 1912; L. Ambronn, *Handbuch der Astronomischen Instrumentenkunde*, II, p. 905-907.)

[11]*Adversaria*, p. 5.

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There exists a series of measurements of the air temperature at Copenhagen in the winter of 1709, made with the new thermometers. These measurements are of especial interest, and were occasionally mentioned in foreign literature.

The winter of 1709 was very severe. In an essay entitled, "The History of the Great Frost in the Last Winter, 1708 and 1708-9,"[12] Dr. Derham writes of the conditions in Denmark. From his discussions we see how great was the progress of Römer, and how far his fundamental idea lay from that of his time, as Derham did not at all understand the principle of his thermometer graduations. Derham writes: (p. 458) "As to the Northern Parts, the before commended Dr. *Woodward* tells me, that in a letter he received from the learned Mr. *Otho Sperling*, from *Copenhagen*, dated *April 6, 1709*, he calleth it *Hymens Atrocissima*. And I find it noted in the minutes of the *Royal Society* of *May 4, 1709*, 'That Dr. *Judichar* said the ice was frozen in the harbour of *Copenhagen* 27 inches; and that *April 9, N. S.*, People had gone over between *Schone* and *Denmark* on the ice,' which Accounts give me a better Opinion of some Papers I have by me, which were showed to the *Society*, concerning the Frost at *Copenhagen*, pretended to be taken from the Observations of Mr. Römer. I should not entertain the least distrust of the Accuracy either of the Instruments or Observations of that eminent Person, were I sure they were his. But there were some Passages and Hints in those Papers that lessened others, as well as my Opinion about them. 'Tis said there, "That such a Frost hath not been known in the Memory of Man in these Countries, and that the Frost on *January* 7, and *February* 23, 1708-9, did very nearly approach the Point of Artificial Freezing."

If we examine the tables of Römer's temperature observations in 1708-9, in the *Adversaria*, it appears that it begins 26 December, 1708, and continues to 9 April, 1709; although from 1 April, 1709, on, observations are not entered for every day,

[12] Dr. W. Derham was a clergyman of the Anglican Church at Upminster, and a frequent contributor to the Royal Society, on meteorological and other subjects. The following quotation is pertinent, though not given by K. Meyer:

W. Derham, *Roy. Soc. Phil. Trans.*, 26, p. 335, 1709.

Speaking of a comparison of his own thermometer observations at Upminster with those of Dr. Joh. Ja. Scheuchzer, in Zurich, he says: "I. For the *Thermometer*: It would have been in vain to have compared his Observations with mine, by reason we have not got a standard for Thermometers, as we have for the Barometers; they being everywhere in all, or most respects, different; some with large, some with small Bottles of Spirits; some accordingly with longer, some with shorter; some with wider, some with narrower Canes, or Shanks; some filled with more highly rectified, and consequently more expansive Spirits, some with more phlegmatic and duller Spirits.

The quotation in the text is from *Roy. Soc. Phil. Trans.* 26, p. 454, 1709.

"The History of the Great Frost in the last Winter, 1708 and 1708-9, by the Rev. Mr. W. Derham, Rector of Upminster, F. R. S.

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doubtless because the table was to record only temperatures under 8°. The notes in the margin are Horrebow's; above the table there stands: "Römer consequently had changed his first proposition." That means, as Horrebow's marginal notes in the *Adversaria* show, that Römer had made the number 8 the melting point, instead of 7 1-2 as previously.

Now the table shows that exactly on 23 February, which Derham mentions specially, the thermometer sank almost to Römer's zero point. Recall the expression with which Derham refers to this fact: "that the Frost on *January* 7 and *February* 23, 1708-9, did very nearly approach the Point of Artificial Freezing." From this it follows that Römer's zero point was exactly the temperature of a freezing mixture,[13] a fact which Derham himself must have got from the information originating in Denmark, as he did not know Römer's scale. The remark has particular interest for the treatment of the question, whether, and if so, in what ways, Römer's thermometer became important to wider circles. The answer is, through Römer's influence on Fahrenheit.

We have direct expressions on this point, first by Boerhaave. He asserts that water can exist in the fluid state at temperatures above 32° Fahrenheit. In this connection he narrates[14] that "the distinguished mathematician Römer in the year 9 of this century observed in Danzig a winter cold (down) to the first degree of this same thermoscope, of which he was himself the inventor."

Here Römer is expressly represented as the first maker of Fahrenheit thermometers. Boerhaave's statement has double importance, as he stood in close relations with Fahrenheit, who had made him thermometers, and whose skill as instrument maker he often mentions with praise. The statement that Römer made measurements in Danzig in 1709 rests on a misunderstanding; as we shall see below, measurements were made with a similar thermometer in Danzig, not by him, but by others. At all events it cannot be shown that Römer was then abroad; his numerous official duties, his delicate health,[15] and particularly the table of temperatures at Copenhagen make this doubly improbable.

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[13]See translator's note at end.

[14]H. Boerhaave, *Elementa Chemiae, Lugduni Batavorum*, 1732, T. 1, p. 720.

[15]His death in 1710 was due to stone, from which he suffered a long time.—W. J. F.

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We find also other statements that Römer was the true inventor of the Fahrenheit thermometer. These can frequently be referred back to Boerhaave. So the English physician Martine writes[16] that the quicksilver thermometers were first invented by Römer; but as he at the same time refers to the just-quoted passage in Boerhaave, we see that he confused the invention of the Fahrenheit thermometer, which was Römer's, and that of the quicksilver thermometer.

In Danzig the matter was gossip, apparently. Hanow writes in Danzig, 25 February, 1736[17] ". . . According to the most accurate weatherglasses, which Herr Römer in Danzig has designed, and which Herr Fahrenheit makes the best, water boils at 212 and freezes at 32 degrees."

In a later enlarged edition of this book by Titius, Leipzig, 1753, reference is made directly to Boerhaave, which Hanow did not. Hanow's views apparently varied. In an essay of 1745 by v. Bergen it is said of Fahrenheit, "To whom Römer, that very zealous friend of the physical and astronomical sciences, had suggested the freezing and boiling limits in the construction of thermometers, if we may believe Hanow in the *Memorabilia Gedanensia.*"[18] This expression has in recent times led E. Gerland, in connection with Hanow, to assert that it was Römer who suggested to Fahrenheit the applicability of freezing point and boiling point in the temperature graduation. At the same time Gerland tries to limit this credit; among other things he says[19] that Fahrenheit's discovery of supercooling[20] taught him to use the melting point of ice, and not, as Römer had advised him, the freezing point of water. As appears from Römer's own papers, he used exactly this melting point of snow, so that it is not probable he advised Fahrenheit otherwise.

Later, Hanow gave up his above-mentioned view about Römer's influence on Fahrenheit, for in the second edition of his treatise, 1757, v. Bergen says[21]:

"In the first edition of this work I say that Fahrenheit owed the excellent idea of these fixed points (freezing point and boiling point) to the keen-minded Römer; but to assert this now I am

[16] Essays Medical and Philosophical, August, 1738; in an essay on thermometers.
[17] Erlauterte Merkwurdigkeiten der Natur, p. 62; (a sort of weekly, published by Hanow.)
[18] De thermometris mensurae constantis Commentatio Francfortii ad Viadrum 1745.
[19] E. Gerland u. F. Traumuller, Geschichte der Experimentierkunst, 1899, p. 249, p. 251.
[20] Roy. Soc. Phil. Trans., 33, p. 81, 1724-5.
[21] v. Bergen, Commentatio de Thermometris, 2. ed., Nurnberg, 1757, p. 22, note.

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forbidden, by a letter which the famous Hanow has written me, in which he says, Römer's arrangement was derived from the then customary graduation of thermometers in the Académie des Sciences at Paris, introduced, if I remember correctly, by de la Hire . . . . . I assent gladly, for I do not at all understand by what accident this important invention was reserved for Fahrenheit, a quite uneducated man; for de la Hire's thermometer is not provided with these fixed points."

We now know certainly that Hanow's account of Römer's scale is inaccurate, but even the fact that he gives it shows that he knew of the existence of a Römer thermometer, without knowing the thermometer itself. Consequently, Gerland's suspicion is untenable, that Hanow had his information from Fahrenheit; further, Gerland says of Fahrenheit, that in 1710 he came to Danzig, and in fact from Copenhagen, where he visited Römer in 1709.

Thus we come to the question, Can an influence of Römer on Fahrenheit be proved, and in what direction? In his biography of Fahrenheit Professor Momber collects[22] what is known with certainty about Fahrenheit's dwelling places at various times; he does not believe that it can be fixed, when Fahrenheit visited Römer; but that he did visit him he regards as settled. Also, the principal source of our information about Fahrenheit's youth, a manuscript in the Royal Library in Berlin, makes this probable; here it is related, that as late as 1706 Fahrenheit was making many laborious journeys on land and water, and had conferences with the famous mathematicians in Denmark and Sweden.[23]

[22] *Schriften der Naturforschenden Gesellschaft* in Dansig, N. S. 7, p. 108, 1890.

[23] My authority here is the *Altpreussische Monatsschrift*, 1874, in which Strehlke has published a fragment of Wuttstrack's "Collectaneen" (materials collected) for his unpublished work, *Historisch-topographisch-statische Nachrichten von Dansig. Bialystok*, 1804.

In a volume of collections in the Royal Library at Berlin, there is the following account, by a foreign hand of the eighteenth century, in the chapter on famous Dansigers (Fahrenheit 1686-1736, written 1740): It is related of his childhood that he was really destined for study, and then—"But by the unexpected and sudden death of both his parents, who left this world 1701, 14 August, in their garden house, this plan was set back, since his guardians found it advisable to dedicate him to trade. To this, therefore, he was obliged to yield (though not without revolt) and (after he for some time received the necessary instruction in bookkeeping) Anno 1702, was sent to Amstegdam to learn the business with Hermann von Beuningen, now dead, where also he remained for the stipulated four years' service; but, instead of continuing in business, his so long hindered natural inclination toward studies spurred him on anew to follow his intended goal. To that end he made many laborious journeys on water and land, conferred with the most famous mathematicians in Denmark and Sweden, sent his instruments to Iceland, Lapland and other places, whence the observations made by interested people were sent to him at Amsterdam; and it is well known (wie den notorisch) that already, Anno 1709, in the severe winter he had made very noteworthy observations with his weatherglasses, of which mention was made in various news items on the occasion of the severe cold occurring in this 1740th year. Ao. 1710, after the end of the pest, he visited his blood friends in Dantsig 1711, he went to Kurland and Liffland, whence, 1712, he returned and cultivated intimate relations with the then living Professor Math. Paul Pater. Ao. 1714, he traveled to Berlin and Dresden, in order to superintend in person the manufacture of the tubes for his instruments in the glass works there, from whence later to Amsterdam, where afterwards he lived continuously." (Beside these journeys, Fahrenheit lived in England at dates not recorded in the reference books which I have examined.—W. J. F.)

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On this Momber says, "These statements seem to me to be especially reliable, since in the first place, as far as they can be checked by source documents, they are found to be true, and, further, written down four years after Fahrenheit's death, their whole character points toward an author who stood in very close relations with him and his family." Professor Momber was so friendly as to communicate to me that he has later found nothing giving definite information about the relations between Fahrenheit and Römer.

From the manuscripts mentioned it is clear that between 1702 and 1710 Fahrenheit was in Denmark and in relations with Römer, that is, exactly at the time when Römer was working on his new thermometers. In Titius' *Oddities of Nature* it is several times mentioned that, 1709, measurements of temperature were madé "with the weatherglass of Fahrenheit, famous in Danzig on account of its accuracy, and in use as early as 1709."[24] Further, he says of this weatherglass, "Wilki's weatherglass, which Krikart owned and described in the year 1709, also agrees. Since this Krikart is said to have owned such a glass as much as twenty years before 1709, but not to have described it before 1708, it seems to have been filled at the beginning of the frost in the year 1708 with fresh spirits by Fahrenheit, and to have been arranged according to his method."[25]

Consequently, it is probable that Fahrenheit met Römer, and, if Boerhaave's statement is correct, in the oldest Fahrenheit thermometers we must trace Römer's influence.

From Römer Fahrenheit could learn the following: the principle of two fixed points as basis of the scale, and the graduation in equal volumes. Fahrenheit has described the construction of his thermometers only briefly[26];—

" . . . . . Two sorts of thermometers are principally made by me, one filled with spirits of wine, the other with quicksilver. Their length varies according to the use they are to serve. They are all alike in this, that the degrees of their scales agree among themselves, and that their variations occur between fixed limits. The scales of thermometers which are intended mainly for meteorological observations begin below at zero and end at the 96th degree. The division of this scale rests on three

[24] Titius, *Seltenheitenheiten der Natur*, p. 666.
[25] l. c., p. 693.
[26] *Roy. Soc. Phil. Trans.*, 33, p. 78, 1724. (This is in Latin: I have translated directly, and somewhat more at length than K. Meyer, rather than retranslate from the German.—W. J. F.)

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fixed limits, which are determined in the following manner: the first of them is found at the bottom or beginning of the scale, and is got with a mixture of ice, water and sal ammoniac or sea salt; if the thermometer is placed in this, the fluid descends to that degree which is marked zero. This experiment succeeds better in winter than in summer. A second boundary is obtained, if water and ice are mixed without the above-mentioned salts. The thermometer being placed in this mixture, the fluid reaches the thirty-second degree, called by me the boundary of freezing, for stagnant water is covered with very thin ice when in winter the fluid of the thermometer reaches this degree. The third boundary is found at the ninety-sixth degree; the spirit expands just to this degree when it is held in the mouth or armpit of a living man in good health so as to acquire perfectly the heat of the body. But if the heat of a man in fever or subject to some other fervent disease is to be tested, another thermometer is used, whose scale is prolonged to 128 or 132 degrees. Whether these degrees are sufficient for the heat of every fervent fever I have not yet found out; though it is hardly to be believed that the fervor of any fever would exceed these degrees. The scale of thermometers with which the degree of heat of boiling liquids is to be tested also begins at zero and contains 600 degrees, for about this degree the mercury (with which the thermometer is filled) itself begins to boil . . . . . "

Here then Fahrenheit tells that the goodness of his thermometers depends on the use of fixed points, between which the graduation is carried out. Of the here mentioned three fixed points only one apparently—the freezing point—corresponds to those used by Römer. From the assertions of Derham, quoted above, it appears that Römer's zero of 1709 was put equal to the temperature of a freezing mixture[27], and the fact that the quicksilver in the severest winter within human memory approached this point had certainly given it a special importance, so that it is not unlikely that Fahrenheit—and perhaps Römer also—chose this limit as a fixed point for such thermometers as were not to indicate temperatures to the boiling point of water. As we shall see in the various scales of 1708 to 1714, which bear Fahrenheit's name, this fixed point was not quite definitely determined; from the words quoted above, "This experiment succeeds better in winter than in summer," we can see that Fahrenheit does not think that he always gets exactly the same temperature. The

[27] See translator's note at end.

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third point is perhaps then introduced as a sort of check. In the earlier years Fahrenheit kept his construction secret and surprised his contemporaries in the highest degree by the agreement among his thermometers.

Fahrenheit's oldest thermometers are mentioned in various places. Grischow[28], especially, gives a detailed collation of the various scales according to which they were graduated. The later discussions, of which Van Swinden's *Dissertation sur les Thermomètres*, Amsterdam, 1778, is very complete, are mainly based on Grischow. According to Grischow[29] and others,[30] Fahrenheit is said to have communicated the secret of his thermometer graduation to his instructor (Repetitor) in mathematics, Barnsdorf, of Rostock; and of it he asserted that anyone, knowing it, could make agreeing thermometers. Grischow writes that this happened about 1712 or 1713, if not earlier. Shortly thereafter Fahrenheit went to Halle and Leipzig; and Barnsdorf, in company with his colleague Lange, tried to make thermometers according to his directions. The scale of these thermometers was somewhat different from that of those which later passed under Fahrenheit's name, and it is said of Barnsdorf that he certainly "had kept Fahrenheit's older or oldest graduation." From a table it is clear that Barnsdorf's thermometers showed 7 1-2 at the freezing point and 22 1-2 at body heat; these degrees are subdivided into smaller, in fact into eight, degrees each. The use of 7 1-2 at the freezing point indicates, in connection with everything else, an influence of Römer. Barnsdorf's zero lies somewhat higher than that of the later Fahrenheit thermometer. We have also other witnesses to the fact that Fahrenheit had used 7 1-2 at the freezing point, and that his zero originally stood somewhat higher than was later the case.

Professor Kirch, Berlin, describes, 1737, his thermometer[31] in connection with certain temperature observations which a friend in Pennsylvania had made with a thermometer of the same sort as his own; this thermometer had been given the friend by Kirch himself, 1727, and in the essay observations by Kirch in the year 1732 are mentioned. Consequently the essay must have been written between 1732 and 1737. Kirch's discussions are contained in the following:

[28] Miscell. Berolienses, T. VI, printed 1740.
[29] l. c., p. 271.
[30] Cotte, Traite de Meteorologie, 1774, p. 129.
[31] Miscell. Berol., 5, p. 129, 1737.

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1. My thermometer, which I have used several years, was made by the so skillful Fahrenheit more than twenty years ago. On it 24 degrees of heat are numbered; 0 denotes the greatest cold and 24 the highest heat. Two more degrees are introduced below zero, so that the degree of cold of the thermometer can be reckoned even when, in the case of extraordinary cold, its fluid contracts so as to withdraw below the limit zero.

2. This is a thermometer of small or medium size; its scale measures 5 Rhenish inches from 0 to the 24th degree. The single degrees are divided into four quadrants, so that from degree zero to the last division line there are 96 quadrants.

3. On the newer Fahrenheit thermometers the scale is no longer divided into 24 degrees and quadrants, but into 96 smaller degrees, corresponding to the 96 quadrants of the 24 degrees in which the older thermometers are divided.

4. The two sorts of graduation can easily be compared, since the quadrants of the larger degrees are quite equal to the smaller degrees.

5. Some years ago I noticed that my thermometer did not entirely agree with others of Fahrenheit, and so I ordered from the famous Mr. Fahrenheit a new and exact thermometer, so as to be able to compare with it my own and other thermometers. I found that this new thermometer agrees well with others of Fahrenheit, but differs noticeably from mine.

In paragraphs 6 and 7 Kirch treats the size of the discrepancies; at the highest and lowest temperatures they are not always the same; at the highest temperature they are 6 1-2 small degrees; at the lowest, 5, since the zero point of the old thermometers lies higher.

In 8, "The boundary between frost and thaw on my thermometer is at 7 1-2; on the new Fahrenheit thermometers at 36." (36 is correctly copied, though unexpected.—W. J. F.)

One more thermometer, perhaps the oldest of all, seems based on a graduation with fixed points and a scale like that of Barnsdorf, although the numbering is quite different. Grischow writes, 1740, that a large thermometer, made by Fahrenheit thirty years before for the Royal Society in Berlin, and consequently with every conceivable care, still agreed perfectly with a small thermometer that Fahrenheit had recently sent from Amsterdam to Berlin. These small thermometers were graduated by means of two or three fixed points and made exactly as we get them today. The first of these thermometers must therefore have been constructed according to quite definite principles[32]; for such an agreement cannot be accidental; a similar thermometer, used for observations 1709, surely one of the first made by Fahrenheit, was still in existence in Danzig in 1740.

This thermometer was apparently graduated like the Florentine; 90° at body heat, 0° at summer heat, 90° at the lowest degree of cold; at the freezing point of water stands 30°. From the

[32] Van Swinden, *Dissertation*, par. 34.

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lowest degree of heat to the freezing point there are then 60 = 8×7 1-2°; from the lowest to the highest heat degree 180° = 8×22 1-2°; it is then apparent that this thermometer graduation is the same as Barnsdorf's, except that the large degrees are divided into eight smaller.

In 1714, Fahrenheit made two concordant thermometers for Freiherr Christian von Wolff, Chancellor of the University at Halle, who was very much pleased with them and has described them.[33] The scale had 26 degrees; the second degree of the scale was designated "greatest cold," and from there on to the upper end there were 24; at the eighth stood "cold." This reminds one exactly of the scale mentioned by Grischow as on the older thermometers of Fahrenheit, with the fixed points 0, 8, 24—later 0, 32, 96. Here Fahrenheit—perhaps like Römer, according to Horrebow's view,—had changed, and chosen 8 instead of 7 1-2. From this we get strong support for thinking that Fahrenheit's fixing of the freezing point at 32° is connected with Römer's directions for it.

In case Römer's scale is reproduced in that of Fahrenheit, one would expect to find the boiling point 4×60 = 240, and not 212. This can, however, be explained.[34] According to the above quoted descriptions of the oldest thermometers the zero of the newer thermometers lies lower than that of the older; if now these latter have the same zero as Römer's thermometer, their degrees must be shorter than those of the newer, since a shorter length contains the same number of degrees. In the newer thermometers the number of the boiling point was found by a division of the range zero (determined by a freezing mixture) to freezing point into 32 equal parts, and the continuation of this beyond the freezing point; since these degrees are longer than the older ones, there are fewer to the same range—hence 212 and not 240 at the fixed boiling point.

The thermometers of Fahrenheit, especially the quicksilver thermometers, are an extraordinarily great step in advance; by them the goal of equal indications for like thermal conditions had been closely approached. Yet till 1775 for the most part people kept on using thermometers of quite different construction, and with graduations which are only with difficulty convertible. In the writings on thermometers of those times one finds extensive tables for the conversion of long forgotten scales, as, e. g.,

[33] *Acta Eruditorum*, p. 381, 1714.
[34] See translator's note at end.

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in Martine, Van Swinden and Lambert. Only three scales have endured to our time. The scale of Réaumur dates from the year 1730,[35] and is a backward step in comparison with Fahrenheit's; it was not originally founded on the application of two fixed points. In his graduation Réaumur used one fixed point and graduated the tube in fractions of the bulb volume. This graduation was done experimentally with the help of little pipettes and funnels; the tube could not then have been a capillary; the bulb must have been about two to three inches in diameter. So, first, this thermometer is very insensitive; second, the determination of the fixed point, the freezing point, is easily inaccurate, for much time must be spent in getting the bulb to the required temperature. Réaumur names 80° as the boiling point only in passing; he will rather make different thermometers agree by graduating their tubes by the method above described and filling them with the same fluid; he proposes to use wine spirit of a strength such that 1,000 volumes on heating from the freezing point to the boiling point of water expand to 1,080 volumes. But the method which he applies for testing this expansion can give no certain results. Later the thermometer of Réaumur was altered to its present generally known form.

Celsius[36] in his thermometer applies a rational sort of graduation; in doing so he takes account of the pressure variation of the boiling point of water.

TRANSLATOR'S NOTE.

A good and accurate account of the development of the thermometer is given by Cajori in his *History of Physics*, based largely on Gerland's book on the thermometer. As Römer's *Adversaria* was not published when these were written, his contributions are not stressed in them. But one must be on his guard against the statement that Huygens advised the employment of *two* fixed points. His letter of January 2, 1665, recommends the use of a tube whose volume is a known fraction of the bulb-volume, and one fixed point, *either* the ice point *or* the steam point. However, he seems to have preceded Halley and Amonton in observing the constancy of the water boiling point. The use of two fixed points, the melting points of ice and of butter, was advised by Dalencé, 1688.

There is discrepancy in the various books as to the date when Fahrenheit began to use mercury. But while some say that

[35] *Hist. et Memoires de l'Academie de Paris, annee* 1730, p. 452.
[36] Vetensk. Akad. Handl. Aar, 1742, p. 171.

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he made thermometers before 1709, I think that the above account by K. Meyer renders it very improbable. She also makes clear, in agreement with others, that Fahrenheit used four scales, thus:

	Maker	Described by	Made	M.Pt.	Bl'd Ht.	B. Pt.	Zero
a	Römer	Römer, before 1710	1702-3	7.5	.....	60	−14.3°C.
b	Römer	Horrebow, after 1739	before 1709	8	?	?	?
a	Fahrenheit	Grischow, 1740	1710?	−30	90	.....	+9.2°C.*
a	Fahrenheit	Kirch, 1732-7	before 1712?	7.5	.....	.....	.....
a	Barnsdorf	Grischow, 1740	1712-3	7.5	22.5	.....	−18.4°C.*
b	Fahrenheit	Fahrenheit, 1724	1724	32	96	.....	−18.4°C.*
.....	Fahrenheit	Kirch, 1732-7	about 1737	36	.....	.....	.....
.....	Fahrenheit	Modern texts	.....	32	.....	212	−17.8°C.

Fahrenheit's and Barnsdorf's *a* seem based on Römer's *a*, but have a different starting point, −18.4° C., (*computed by taking the mean blood heat = 36.875° C.;) Fahrenheit's *b* is based on Römer's *b*, whose starting point is not known; though K. Meyer asserts, on what seems the inadequate evidence of Dr. Derham's account, that it was a freezing mixture temperature. However, Fahrenheit's *a* and *b* and Barnsdorf's *a* have the same starting point, −18.4° C.

Suspicions are voiced by some authors that Fahrenheit did not describe his actual method in his Philosophical Transactions account of 1724. And it does seem hard to believe that such good agreement as his instruments are reported to have shown could have been obtained with the shifting and uncertain zero point got "with a mixture of water, ice and sal ammoniac or sea salt," an experiment which worked "better in winter than in summer."

It may also be noted that Landolt and Björnstein, 1905, give the following values for the eutectic points of the mixtures used by Fahrenheit:

Ice 100 parts	Salt 28.9 parts	−21.2°C.
Ice 100 parts	Sal ammoniac 22.9 parts	−15.8°C.

Both of these are temperatures which differ considerably from the starting points of the Römer scale, −14.3°, and the Fahrenheit scales, −18.4° or −17.8°.

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THE DUTY OF THE EMPLOYER IN THE RECONSTRUCTION OF THE CRIPPLED SOLDIER.

By Douglas C. McMurtrie,

Director Red Cross Institute for Crippled and Disabled Men, New York City.

We must count on the return from the front of thousands of crippled soldiers, and we must plan to give them on their return the best possible chance for the future.

Dependence cannot be placed on monetary compensation in the form of a pension, for in the past the pension system has proved a distinct failure in so far as constructive ends are involved. The pension has never been enough to support in decency the average disabled soldier, but it has been just large enough to act as an incentive to idleness and semi-dependence on relatives or friends.

The only compensation of real value for physical disability is rehabilitation for self-support. Make a man again capable of earning his own living, and the chief burden of his handicap drops away. Occupation is, further, the only means for making him happy and contented.

Soon after the outbreak of hostilities, the European countries began the establishment of vocational training schools for the rehabilitation of disabled soldiers. They had both the humanitarian aim of restoring crippled men to the greatest possible degree and the economic aim of sparing the community the burden of unproductivity on the part of thousands of its best citizens. The movement had its inception with Mayor Édouard Herriot of the city of Lyons, France, who found it difficult to reconcile the desperate need for labor in the factories and munition works, while men who had lost an arm or a leg but were otherwise strong and well, were idling their time in the public squares. He, therefore, induced the municipal council to open an industrial school for war cripples, which has proved the example and inspiration for hundreds of similar schools since founded throughout France, Italy, Germany, Great Britain, and Canada.

The disability of some crippled soldiers is no bar to returning to their former trades, but the injuries of many disqualify them from pursuing again their past occupations. The schools of training prepare these men for some work in which their physical handicap will not materially interfere with their production.

The education of the adult is made up largely of his working experience. The groundwork of training in his past occupation must under no circumstances be abandoned. The new trade must be related to the former one or be, perhaps, an extension or specialization of it. For example, a man who had done manual work in the building trades may by instruction in architectural drafting and the interpretation of plans be fitted for a foreman's job, in which the lack of an arm would not prove a serious handicap. A trainman who had lost a leg might wisely be prepared as a telegrapher, so that he could go back to railroad work, with the practice of which he is already familiar.

Whatever training is given must be thorough, for an adult cannot be sent out to employment on the same basis as a boy apprentice. He must be adequately prepared for the work he is to undertake.

The one-armed soldier is equipped with working appliances which have supplanted the old familiar artificial limb. The new appliances are designed with a practical aim only in view; they vary according to the trade in which the individual is to engage. For example, the appliance for a machinist would be quite different from that with which a wood turner would be provided. Some appliances have attached to the stump a chuck

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in which various tools or hooks can interchangeably be held. The wearer uses these devices only while at work; for evenings and holidays he is provided with a "dress arm," which is made in imitation of the lost natural member.

An important factor in the success of re-educational work is an early start, so that the disabled man shall have no chance to go out unemployed into the community. In even a short period of exposure to the sentimental sympathy of family and friends, his "will to work" is so broken down that it becomes difficult again to restore him to a stand of independence and ambition. For this reason, therefore, the plan for his future is made at as early a date as his physical condition admits, and training is actually under way before the patient is out of the hospital.

In the readjustment of the crippled soldier to civilian life, his placement in employment is a matter of the greatest moment. In this field the employer has a very definite responsibility. But the employer's duty is not entirely obvious. It is, on the contrary, almost diametrically opposite to what one might superficially infer it to be. The duty is not to "take care of," from patriotic motives, a given number of disabled men, finding for them any odd jobs which are available, and putting the ex-soldiers into them without much regard to whether they can earn the wages paid or not.

Yet this method is all too common. A local committee of employers will deliberate about as follows: "Here are a dozen crippled soldiers, for whom we must find jobs. Jones, you have a large factory; you should be able to take care of six of them. Brown, can you not find places for four of them in your warehouse? And Smith, you ought to place at least a couple in your store."

Such a procedure cannot have other than pernicious results. In the first years of war the spirit of patriotism runs high, but experience has shown that men placed on this basis alone find themselves out of a job after the war has been over several years, or, in fact, after it has been in progress for a considerable period of time.

A second weakness in this method is that a man who is patronized by giving him a charity job comes to expect as a right such semi-gratuitous support. Such a situation breaks down, rather than builds up, character, and makes the man progressively a weaker rather than a stronger member of the community. We must not do our returned men such injury.

The third difficulty is that such a system does not take into account the man's future. Casual placement means employment either in a makeshift job as watchman or elevator operator—such as we should certainly not offer our disabled men except as a last resort—or in a job beyond the man, one in which, on the cold-blooded considerations of product and wages, he cannot hold his own. Jobs of the first type have for the worker a future of monotony and discouragement. Jobs of the second type are frequently disastrous, for in them a man, instead of becoming steadily more competent and building up confidence in himself, stands still as regards improvement and loses confidence every day. When he is dropped or goes to some other employment, the job will have had for him no permanent benefit.

Twelve men sent to twelve jobs may all be seriously misplaced, while the same twelve placed with thought and wisdom and differently assigned to the same twelve jobs may be ideally located. If normal workers require expert and careful placement, crippled candidates for employment require it even more.

The positive aspect of the employer's duty is to find for the disabled man a constructive job, which he can hold on the basis of competency alone. In such a job he can be self-respecting, be happy, and look for-

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ward to a future. This is the definite patriotic duty. It is not so easy of execution as telling a superintendent to take care of four men, but there is infinitely more satisfaction to the employer in the results, and infinitely greater advantage to the employee. And it is entirely practical, even in dealing with seriously disabled men.

A cripple is only debarred by his disability from performing certain operations. In the operations which he can perform, the disabled man will be just as efficient as his non-handicapped colleague, or more so. In the multiplicity of modern industrial processes it is entirely possible to find jobs not requiring the operations from which any given type of cripples are debarred. For such jobs as they can fill the cripple should be given preference.

Thousands of cripples are now holding important jobs in the industrial world. But they are men of exceptional character and initiative and have, in general, made their way in spite of employers rather than because of them. Too many employers are ready to give the cripple alms, but not willing to expend the thought necessary to place him in a suitable job. This attitude has helped to make many cripples dependent. With our new responsibilities to the men disabled in fighting for us, the point of view must certainly be changed. What some cripples have done, other cripples can do—if only given an even chance.

The industrial cripple should be considered, as well as the military cripple, for in these days of national demand for the greatest possible output there should not be left idle any men who can be made into productive workers.

With thoughtful placement effort, many men can be employed directly on the basis of his past experience. With the disabled soldiers who profit by the training facilities the government will provide, the task should be even easier.

This, then, constitutes the charge of patriotic duty upon the employer: To study the jobs under his jurisdiction to determine what ones might be satisfactorily held by cripples; to give the cripples preference for these jobs; to consider thoughtfully the applications of disabled men for employment, bearing in mind the importance of utilizing, to as great an extent as possible, labor which would otherwise be unproductive; to do the returned soldier the honor of offering him real employment, rather than proffering him the ignominy of a charity job.

If the employer will do this, it will be a great factor in making the complete elimination of the dependent cripple a real and inspiring possibility.

THERMAL INSULATION.

The importance of thermal insulation as a factor in coal saving in steam plants under present conditions was emphasized at a recent meeting of the Providence (R. I.) Engineering Society in a paper by L. B. McMillan, consulting engineer, general power specialties department, H. W. Johns-Manville Company, New York. At present fuel costs, the author said, the losses of heat encountered in uninsulated pipe and fittings are very serious The loss of heat per square foot of bare pipe at 100 pounds pressure may easily represent the equivalent of more than one-third of a ton of coal per year at the pipe surface alone, or more than one-half ton at 150 pounds. The loss at the coal pile itself may be five or ten times as great. More attention should be given to insulating pipe flanges than in the past. A 10-inch bare flange at ordinary steam-plant pressures like the above may cost more than a ton of coal per year in fuel loss. From 80 to 90 per cent of these losses can be prevented.—[*Electrical World.*

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SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Glidden Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Lists of questions are acknowledged from P. F. Hammond, University of Alberta, and W. P. Akin, Wichita Falls, Texas.

Science Tests.

Partial reports on tests as sent out by the Editor have been returned by the following:

O. W. Baird, Stadium High School, Tacoma, Wash.

H. E. Hammond, Central High School, Kalamazoo, Mich.

C. Arthur Smith, East High School, Salt Lake City, Utah.

J. L. Sloanaker, North Central High School, Spokane, Wash., and W. P. Akin, Wichita Falls High School, Wichita Falls, Texas, have asked to be enrolled among those interested in tests.

Tests on mechanics and on chemistry will soon be prepared and mailed to all who are on the list. Your assistance will be greatly appreciated.

QUESTIONS AND PROBLEMS FOR SOLUTION.

307. *Proposed by G. Ross Robertson, Riverside, Cal.*

Why is the rust, or tarnish, or corroded surface of common lead, grey or black? (The oxides of lead are yellow, red, or brown.)

308. Are the following questions *suitable* for school boys and girls, (granting that it is easily possible to teach them so that they may "pass" an examination)? If not, propose a few "test" questions of your own.

Physics.

College Entrance Examination Board, Friday, June 21, 1918 (Two Hours).

Answer ten questions as indicated below. No extra credit will be given for more than ten questions. Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

Group 1. (*Omit one question from this group.*)

1. (*a*) Explain the meaning of the terms acceleration, work, power, momentum, moment of a force.

(*b*) A balance has unequal arms, the left-hand arm having a length 99 per cent of that of the right-hand arm. A dealer has the habit of putting in the left-hand pan the articles which he sells. Who gains, the dealer or the customer? Why?

2. The water passing through the turbine water wheels at the Niagara power plant has fallen 136 feet. The average horse power of the turbines is 5,000 and their efficiency is 85 per cent. How many cubic feet of water does each turbine discharge per minute? (One cubic foot of water weighs 62.4 pounds.)

3. A painter's platform is 18 feet long and weighs 100 pounds. Its center of gravity is 8.5 feet from the right-hand end. The platform is hung in a horizontal position by two ropes, one attached one foot from one end, the other one foot from the other end. When a painter weighing 150 pounds stands at a point 7 feet from the left-hand end of the platform what weight does each rope support?

4. An aeroplane one mile above the earth is moving horizontally with a velocity of 60 miles per hour. A bomb is dropped from it in an attempt to hit a station. When the bomb is released, how far should the aeroplane be from the point ahead in its path which is directly over the station?

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GROUP II. (*Omit one question from this group.*)

5. Describe an experiment, perferably one which you have personally performed, by which the wave length of a musical sound may be determined.

6. A man is standing two miles in front of a cliff. A gun, located between the man and the cliff, is fired. The man hears the report of the gun and, four seconds later, hears the echo of the report from the cliff. Taking the temperature of the air as 0°C., find the distance from the gun to the cliff.

GROUP III. (*Omit one question from this group.*)

7. Describe an experimental method of determining the coefficient of expansion of a gas under constant pressure.

8. A Centigrade mercury thermometer contains in its bulb and capillary tube up to the 0° mark .15 cubic centimeter of mercury. If the diameter of the capillary tube is .012 centimeter, what is the length of the tube from the 0° mark to the 100° mark? (The coefficient of apparent expansion of mercury in glass is .000156.)

9. How many kilograms of coal would be needed in a boiler having an efficiency of 65 per cent to convert 50 kilograms of water at 10° C. into steam at 100° C.? Assume that the heat value of the coal is 7,000 calories per gram.

GROUP IV. (*Omit one question from this group.*)

10. (*a*) Explain in terms of the wave theory of light the production of a spectrum by means of a prism.

(*b*) Describe the appearance of the solar spectrum.

11. (*a*) Describe an experimental method of determining the index of refraction of glass.

(*b*) The index of refraction of glass being 1.5, find the speed of light in it.

12. The works of a watch are held 1.5 inches from a jewler's eye-lens which has a focal length of 1.75 inches. How many times are the works magnified?

GROUP V. (*Omit one question from this group.*)

13. Using diagrams describe an electric telephone transmitter and an electric telephone receiver and explain the action of each.

14. A total current of 24 amperes flows through two branches of a divided circuit having resistances of 7 and 5 ohms, respectively. Find

(*a*) The strength of current which flows through each branch.

(*b*) The electromotive force required to maintain the current.

15. An electric motor having an efficiency of 85 per cent develops 3 horse power when connected to a 220-volt circuit. How much current flows through the motor? (One horse power = 746 watts.

AGRICULTURE.

University of Alberta Matriculation Examination, May, 1918. (*Two and One-Half Hours.*)

1. What is a seed? What is the importance, (1) to the crop grower, (2) to the consumer, of each of the following parts of a wheat seed? (*a*) The embryo; (*b*) the endosperm; (*c*) the epidermis of bran.

2. Compare the corn or wheat and pea or bean seed as follows: (*a*) before germination; (*b*) during the process of germination; (*c*) root and stem development following germination.

3. Discuss soil under the following headings: (*a*) origin; (*b*) color; (*c*) heavy and light soil; (*d*) open and compact soil; (*e*) rich and poor soil.

4. Define water holding capacity as applied to soil. Discuss each of the following in relation to its water holding capacity and give reasons for your answer: (*a*) sandy soil; (*b*) gumbo soil; (*c*) clay loam soil; (*d*) well cultivated soil (fallowed); (*e*) poorly cultivated soil (fall-plowed stubble); (*f*) soil low in humus or organic matter; (*g*) soil full of coarse strawy manure; (*h*) soil with a gravelly subsoil; (*i*) soil with a clay subsoil.

5. What effect does each of the following have upon the temperature

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of the soil during the growing season? (*a*) Kind of soil; gumbo, sand and loam; (*b*) deep plowing of the summer fallow; (*c*) harrowing; (*d*) packing or rolling; (*e*) continued drought—a dry soil; (*f*) a dark colored soil; (*g*) a northern exposure.

6. (*a*) Describe two common plant diseases that injure farm or garden crops and give methods for the control of one.

(*b*) Give a description of: (1) ball mustard; (2) stink weed (French weed); (3) perennial sow thistle; and outline a method of controlling each.

7. What is the importance of bacteria to the agriculturist?

What do you understand by: (*a*) nitrogen-fixing bacteria; (*b*) denitrifying bacteria; (*c*) nitrifying bacteria?

What is the significance of introducing the appropriate bacteria into the soil when sowing alfalfa? What are the conditions necessary for the best bacterial reaction in the soil? How can the tiller of the soil control or influence this reaction?

EXCHANGE YOUR FIRST AND SECOND LIBERTY BONDS FOR THOSE BEARING 4 1-4 PER CENT INTEREST.

Bonds of the First and Second Liberty Loans may now and until November 9, 1918, be converted into 4 1-4 per cent bonds. Bonds delivered upon conversion will have the same maturity as the bonds surrendered. In all other respects they will be identical with the bonds of the Third Liberty Loan. This conversion may be effected through the subscriber's bank.

Holders of 4 per cent bonds of the First Liberty Loan Converted, presenting them for conversion on or before November 9, 1918, will receive in exchange, without an adjustment of interest, 4 1-4 per cent Gold Bonds of 1932-47, bearing interest at the increased rate from June 15, 1918.

Holders of 4 per cent bonds of the Second Liberty Loan, presenting them for conversion on or before November 9, 1918, will receive in exchange, without an adjustment of interest, 4 1-4 per cent Gold Bonds of 1927-42, bearing interest at the increased rate from May 15, 1918.

Holders of coupon bonds may receive at their option either coupon bonds or registered bonds; but registered bonds only will be delivered upon conversion of registered bonds, and such bonds will be registered only in the same name as the bonds surrendered for conversion. When registered bonds are presented for conversion, they should be assigned to "The Secretary of the Treasury for Conversion," on the form appearing on the backs of registered bonds. Such assignments, however, need not be witnessed.

All unmatured coupons must be attached to the bonds presented for conversion, and all matured coupons must be detached.

Holders of 3 1-2 per cent bonds of the First Liberty Loan, presenting them for conversion on or before November 9, 1918, will receive in exchange 4 1-4 per cent Gold Bonds of 1932-47, bearing interest at the increased rate from June 15, 1918, but such holders must pay the United States Government accrued interest at the rate of 3-4 per cent of 1 per cent per annum from June 15, 1918, to the date of conversion.

The conversion privilege on 4 per cent bonds of both the First and Second Liberty Loans expires on November 9, 1918, and they cannot be converted into subsequent issues of United States bonds which might come out at a higher rate. Therefore, holders of 4 per cent Liberty Loan Bonds should in every case present them for conversion. By converting these bonds they will not only receive 1-4 per cent of 1 per cent additional interest, but after the conversion period has expired (November 9, 1918) there will undoubtedly be several points difference in the market price of the 4 per cent and 4 1-4 per cent bonds.

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

Correction.

In connection with the proofs of No. 554 published in the May number, the Editor's attention has been called to the fact that the proof by I. E. Kline credited to Loomis was really first published in the American Mathematical Monthly (February, 1902) by G. I. Hopkins of Manchester, N. H. It also appears in Hopkins' book, *Inductive Geometry*, and Loomis acknowledges the authorship of the proof.

SOLUTION OF PROBLEMS.

Algebra.

561. *Proposed by the Editor.*

Factor

$x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz.$

I. *Solution by Garland Martin, First Year Pupil, Warren (R. I.) High School.*

$$\begin{aligned} & x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz \\ &= (xy^2+2xyz+xz^2)+(x^2y+x^2z)+(y^2z+yz^2) \\ &= x(y+z)(y+z)+x^2(y+z)+yz(y+z) \\ &= (y+z)(xy+xz+x^2+yz) \\ &= (y+z)[(x^2+xy)+(xz+yz)] \\ &= (y+z)[x(x+y)+z(x+y)] \\ &= (y+z)(x+y)(x+z). \end{aligned}$$

II. *Solution by Thomas Griffith, Junior, Riverside Polytechnic High School, Cal.*

$$\begin{aligned} & x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz \\ &= x(xz+xy+yz)+y(xz+xy+xz)+xz^2+yz^2 \\ &= (x+y)(xz+xy+yz)+(x+y)z^2 \\ &= (x+y)[x(y+z)+z(y+z)] \\ &= (x+y)(x+z)(y+z). \end{aligned}$$

III. *Solution by Ruth A. David, Gibson City, Ill.*

By the factor theorem, the expression reduces to zero by the substitution $x = -y$. $\therefore x+y$ is a factor. Dividing the given expression by $x+y$, the other factor is found to be $xy+xz+z^2+yz$. This may readily

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be factored by grouping so as to show the common binomial factor $y+z$, the other factor being $x+z$.

$\therefore x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz = (x+y)(y+z)(x+z)$

A second solution was also received from RUTH A. DAVID. *Solutions were also received from* CHAS. BRITTON, LOUISE E. CHURCH, K. C. FITCH, NELLIE F. HENDERSON, EMMA V. HESSE, S. J. KEUSCH, MURRAY J. LEVENTHAL, HAROLD M. LUFKIN, R. M. MATHEWS, M. B. MESSINGER, RALPH MOODY, EDWARD J. O'LEARY, MARGARET O'NEILL, NORRIS OLSON, HOWARD R. PARK, EVERETT ROBINSON, PHILOMATHE, WALTER S. RODGERS, NELSON L. RORAY (2), H. H. SAMPSON, V. M. SPUNAR, DONALD C. STEELE, SYLVIA SILVERMAN, HENRY S. TITUS, JACOB A. WEISS, JOSEPHINE WIBLE *and* HARRIET A. WILCOX.

562. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

If n is a prime number, show that

$$\underline{|n-1}+1 \text{ is a multiple of } n.$$

Solution by Philomathe, Montreal, Can.

I. *Lemma.*—If n is a prime number, the product $2\cdot3\cdot4\cdot\cdots\cdot(n-3)(n-2)$ is a multiple of n, plus 1.

Let A be any factor of the product $2\cdot3\cdot4\cdot\cdots\cdot(n-3)(n-2)$, then there is another factor A′ of the same product, and only one, such that $A\times A' = \text{mult. } n, +1$. For, if we divide $A\times1, A\times2, A\times3, \cdots$, $A(n-1)$ by n we obtain for remainders, in any order, $1\cdot2\cdot3\cdot4\cdot\cdots$, $n-2, n-1$. The multiple of A giving 1 as remainder is neither $A\times1$, nor $A\times A$, nor $A(n-1)$, as could be easily made evident. Therefore, there exists a number A′, and only one, in the product $2\cdot3\cdot4\cdot\cdots\cdot(n-2)$ such that $A\times A' = \text{mult. } n, +1$.

Now, the product $2\cdot3\cdot4\cdot\cdots\cdot(n-2)$ has an even number of factors, and it may be decomposed in groups of two factors, each group being a multiple of n, plus 1. Therefore, the product $2\cdot3\cdot4\cdot\cdots\cdot(n-2)$ is also a multiple of $n, +1$.

Theorem: $\underline{|n-1}+1$ is a multiple of n

Proof. From the lemma,

$$1\cdot2\cdot3\cdot4\cdot\cdots\cdot(n-3)(n-2) = \text{mult. } n, +1$$

Multiply both numbers by $n-1$.

$$\underline{|n-1} = (\text{mult. } n, +1)(n-1)$$

or $$\underline{|n-1} = \text{mult. } n, -1$$

$$\therefore \underline{|n-1}+1 = \text{mult. } n.$$

Note. This is Wilson's theorem.

Geometry.

563. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Using the figure for the Theorem of Pythagoras as given on page 194 of Wentworth's *Plane Geometry* (Edition of 1899), prove

(1) BK, AL and FC are concurrent.

(2) Let X be the intersection of FC and AB, then GX, AD and BC are concurrent.

Prove by means of theorems that are usually given in Book I of plane geometry.

Solution by Philomathe, Montreal, Canada.

I. Let FG and KH meet at O. Then it can easily be proved that FC is $\perp$ to BO, BK is $\perp$ to CO, OA produced is $\perp$ to BC, $\therefore$ coincident with AL. Hence, FC, BK, AL are concurrent.

II. Next, produce AB in M, making BM = AC, and join MF, MG, MC; FC is $\perp$ to MG, MA is $\perp$ to GC, $\therefore$ GX produced is $\perp$ to MC. Now, let Y be the intersection of AD and MC; join XY, which is $\parallel$ to MF or BD. In triangle XYC, DA is $\perp$ to XC, BC is $\perp$ to XY, GX (produced) is $\perp$ to YC; $\therefore$ GX, AD and BC are concurrent.

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564. *Proposed by N. P. Pandya, Sojitra, B. B. and C. I. Ry., India.*

ABC is a triangle, right-angled at A. AP, AQ are squares on AC, AB, respectively. PB cuts AC at D. QC cuts AB at E. Show that DE is parallel to PQ.

I. *Solution by Emlyn Roberts, Pupil Dunmore (Penna.) High School.*

Let M be the vertex of the square AQ opposite B and R opposite C. Produce lines QM and RP and letter their intersection T. Triangle BAD is similar to triangle BRP. Line AD is parallel to line RP. Then BA : BR = AD : RP. Triangle QPC is similar to triangle QAE, line AE is parallel to line PC. Then QA : QP = AE : CP. Substituting CP's equal, AR, we get QA : QP = AE : AR. Triangle QBA is similar to triangle QTP, angle QTP equals angle QBA and angle TQA equals angle BAQ (alternate interior angles.) Then BA : QT = QA : QP; substituting equals, BA : BR = QA : QP.

From the three equations,

BA : BR = AD : RP,
QA : QP = AE : AR,
BA : BR = QA : QP,

AD : RP = AE : AR. Angle EAD equals the angle ARP (right angles.)

Therefore triangle EAD is similar to triangle ARP. Angle RAP equals angle AED, then ED is parallel to QP (if two lines are cut by a transversal and the corresponding angles are equal the lines are parallel).

II. *Solution by Emma V. Hesse, Petaluma High School, Petaluma, Calif.*

Produce DE to meet PC at X and BQ at Y. Then the rt. $\triangle$s XCD, DAE and EBY are similar.

Hence DC/DA = XD/DE, (1) and AE/EB = DE/EY. (2)

Multiply (1)$\times$(2): DC/DA $\cdot$ AE/EB = XD/DE $\cdot$ DE/EY.

Cancel DE, and DC/DA $\cdot$ AE/EB = XD/EY.

Since DC/EB = XD/EY, AE/DA must = 1, that is, AE = DA; $\triangle$ADE is isosceles, and so must $\triangle$XDC.

$\therefore$ $\angle$CXD = 45°

But $\angle$CPA = 45°, $\therefore$ $\angle$CXD = $\angle$CPA.

$\therefore$ DE (produced) is parallel PQ.

II. *Solution by Nellie F. Henderson, Martins Ferry, Ohio, and R. M. Mathews, Riverside (Cal.) Polytechnic High School and Junior College.*

If PB and QC intersect at O, then $\triangle$s QBO and DCO are similar and QO/OC = BO/OD.

Also $\triangle$s BEO and POC are similar and EO/OC = BO/OP.

Divide first equation by the second and QO/EO = PO/DO.

$\therefore$ DE || QP.

Solutions were also received from Ruth A. David, Paul W. Harnley, Murray J. Leventhal, Philomathe (2), Oscar J. Johnson, Nelson L. Roray, Jason A. Zurflich, *and one with no name attached.*

565. *Proposed by L. E. Lunn, Heron Lake, Minn.*

Prove that the lines joining the vertices of a tetrahedron to the centers of the opposite faces are concurrent at the centeroid of the tetrahedron and are quadrisected at this point. Use only elementary geometry.

Solution by R. M. Mathews, Riverside, California.

In tetrahedron ABCD let M be the center of edge CD, G_1 the centroid of face BCD and G_2 that of face ACD.

The three planes determined by one vertex and the median lines of the opposite face are coaxial for they contain said vertex and the centroid of that face. Each pair of these axes lies in one plane and they intersect. Thus AG_1 and BG_2 lie in plane ABM. When each of four non-coplanar lines cuts each of the others they are concurrent. So the axes meet at a point O.

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Consider $\triangle ABM$. A parallel to AG_1 through G_2 cuts MG_1 in X such that $XG_1 = 2/3\ MG_1$. But MG_1 is 1/3 MB, whence $XG_1 = 2/9$ MB $= 2/8$ XB $= 1/4$ XB. $\therefore G_2O = 1/4\ G_2B$.

A solution was received from MURRAY J. LEVENTHAL *and one incorrect solution.*

Late Solutions Received.

554. Two solutions from A. E. Breece.
555. R. M. Mathews.
557. Gerald W. Willard, Heron Lake (Minn.) High School, N. P. Pandya.
560. N. P. Pandya.

PROBLEMS FOR SOLUTION.

Geometry.

576. *Proposed by G. Ross Robertson, Polytechnic High School and Junior College, Riverside, Cal.*

Construct an equilateral triangle with one vertex on each of three given unequally spaced parallel lines.

577. *Proposed by M. Costello, Brentwood, Cal.*

Construct a circle passing through two given points and bisecting a given circle.

578. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Equilateral triangles are constructed outward upon the sides of any triangle. Prove by elementary geometry only that the given triangle and the equilateral triangle whose vertices are the centroids of the equilateral triangles have the same median point.

579. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

Two circles intersect at A and B. The sides DE, FD of a triangle touch both circles. EF intersects AB in C. If AB : AC = EK : EC, where K is the mid point of EF, find the possible positions of EF.

Trigonometry.

580. *Proposed by R. N. Mathews, Riverside, Cal.*

If P is the Brocard point of a triangle such that the angles PAB, PBC, PCA are equal, and p_1, p_2, p_3 its distances to a, b, c, respectively, then $p_1 : p_2 : p_3 = (a+c) : (a+b) : (b+c)$.

S. O. S.

The editor needs a fresh supply of good algebra problems.

P. S. Do not neglect the other kinds of problems.

P. P. S. Many problems proposed have been published before, either in books or in this journal. New practical problems are especially welcome.

PERSONALS.

Menton Rowand, recently principal of the high school at Bellefontaine, Ohio, has been appointed superintendent of schools at Zanesville, Ohio.

Professor Florian Cajori of Colorado College has been made professor of the history of mathematics at the University of California, Berkeley.

Associate Professor B. Clifford Hendricks, who has for the past ten years served the Peru, Neb., State Normal School in its department of physical science and nature study, has accepted a call to a position as assistant professor of general and physical chemistry in the University of Nebraska.

Mr. R. M. Mathews, for many years in connection with the high school at Riverside, Cal., has been made head of the department of mathematics in the Central High School, Duluth, Minn.

Professor Philip B. Woodworth, dean of electrical engineering of Lewis Institute, Chicago, has entered the Government service as a major in the aviation section of the Signal Corps.

Professor M. E. Graber, fellow in mathematical physics at the Univer-

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sity of Chicago, has been elected to the professorship of mathematics in Heidelberg University, Tiffin, Ohio.

Mr. Louis M. Sears, for several years instructor in the Hyde Park, Chicago, High School, has accepted a position in the geography department at the Chicago Normal College.

Professor A. A. Michelson, head of the department of physics, University of Chicago, has been commissioned as lieutenant-commander in the Navy.

Professor G. A. Miller, of the University of Illinois, and associate editor of this Journal, has accepted the chairmanship of a committee which is to make a survey of the mathematical instruction given under the auspices of the Y. M. C. A. at the various naval stations.

W. V. Lovitt, Ph. D., Chicago, of the mathematical department of Purdue University, has been appointed associate professor of mathematics in Colorado College.

Dr. Elias J. Durand has been appointed professor of botany in the University of Minnesota. Dr. Durand was formerly an instructor at Cornell, but since 1910 has held a professorship in the University of Missouri.

Mr. Franklin T. Jones, who for many years has been dean of the University School, Cleveland, and since its beginning Editor of the Department of Science Questions in this Journal, has accepted a position with the Glidden Company, Cleveland, manufacturers of paints and varnishes, as their chemist. Mr. Jones will continue to act as Editor of Science Questions.

Dr. F. S. Nowlan, of Columbia University, has been appointed instructor in mathematics in Bowdoin College.

Professor Julius Stieglitz, chairman of the department of chemistry at the University of Chicago, has been appointed as special expert in the United States Public Health Service of the Treasury Department. This will not involve his work at the university. The Government assigns him two assistants, who will be in the employ of the Public Health Service and will carry out their work in Kent Chemical Laboratory under Professor Stieglitz's direction.

Assistant Professor Harvey B. Lemon, of the department of physics, University of Chicago, has been commissioned captain in the Ordnance Department of the Army and assigned to duty as head of the instrument division of the proof department of the Aberdeen Proving Ground, Aberdeen, Md.

Professor J. H. Ransom, after eighteen years in Purdue University, has accepted the professorship of chemistry and director of the chemical laboratories in Vanderbilt University, Nashville, Tenn.

Professor Henry Blumberg, of the University of Nebraska, has accepted a position in the mathematical department of the University of Illinois.

Professor E. V. Huntington, President of the Mathematical Association of America, has taken leave of absence from Harvard University and with the rank of major in the National Army is assigned to statistical study under the chief of staff with residence in Washington.

Professor A. D. Cole, professor of physics at Ohio State University, was in Washington during the summer, engaged in research work in the Bureau of Standards.

Dr. Richard C. Maclaurin, President of Massachusetts Institute of Technology, has accepted the appointment of director of college training, in charge of the students' Army Training Corps under the War Department's Committee on Education and Special Training, aiming to mobilize the higher institutions of learning.

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Professor E. G. Lange of the Geography Department of the Whitewater Normal School, Wis., has resigned to enter Army Y. M. C. A. work.

Mr. J. A. Nyberg, for the past year instructor in mathematics in the Hyde Park, Chicago, High School, has received an appointment as instructor in mathematics in the Artillery Department of the United States Army.

Professor W. R. McConnell, of the geography department of the Platteville, Wis., Normal School, has been elected head of the department of geography in the Teachers Training College, Miami University, Ohio.

Dr. A. D. Brokaw, assistant professor of mineralogy and chemical geology at the University of Chicago, has been called to Washington to take charge of the oil production east of the Rocky Mountains.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for July; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "A New Three-Salt Nutrient Solution for Plant Cultures," B. E. Livingston and W. E. Tottingham; "The Histology of the Phloem in Certain Woody Angiosperms," L. H. MacDaniels; "Cell Division by Furrowing in Magnolia," Clifford H. Farr.

American Mathematical Monthly, for June; *27 King Street, Oberlin, Ohio; $3.00 per year:* "On the I-Centers of a Triangle," N. Altshiller; "Note on Continuous Functions," K. P. Williams; "Note on Functions Which Approach a Limit at Every Point of an Interval," E. W. Chittenden; "The Nine-Point Circle Obtained by Methods of Projective Geometry," H. N. Wright; "Problems and Solutions."

Geographical Review, for August; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Alsace-Lorraine and Europe" (one insert map in color, five photos), Lucien Gallois; "Two Traverses Across Ungava Peninsula, Labrador" (one insert map, twelve photos), Robert J. Flaherty; "Traveling in China's Southland" (seven photos), Roy Chapman Andrews; "Portugal: The Country and The People" (six photos), William Thompson; "The Rumanians in Hungary" (three insert maps in color, one text map, two diagrams), B. C. Wallis.

Journal of Educational Psychology, for April; *Warwick and York, Baltimore; $3.00 per year, 50 cents a copy:* "An Experimental Study of Methods in Teaching High School Chemistry," William H. Wiley; "A Test in First-Year Chemistry," J. Carleton Bell; "The Range of Information Test in Biology. I. Physiology," N. M. Grier.

Journal of Geography, for May; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Finland," W. H. Twenhofel; "The Natural Resources of Australia," Stephen S. Visher; "The Project-Problem Method of Teaching Geography," Mendel E. Branom; "The Geography of Palestine," W. O. Blanchard; "The Magnesite Industry of Stevens County, Washington," C. E. Cooper; "Fur Seals and the Fur Seal Fisheries," Florence Whitbeck.

Popular Astronomy, for August-September; *Northfield, Minn.; $3.50 per year:* "Mars in 1911 and 1914" (Plate XV, Frontispiece), Latimer J. Wilson; "The Telescope and Mars" (Plates XV and XVI), Latimer J. Wilson; "Star Clusters," Russell Sullivan; "Nebular Evolution" (To be Continued), F. J. B. Cordeiro; "The Total Solar Eclipse of June 8, 1918" (Plate XVII), H. C. Wilson; "Total Solar Eclipse, June 8, 1918, Edwin B. Frost; "The Lowell Observatory Solar Eclipse Expedition," V. M. Slipher; "The Application of Schaeberle's Method in the Photography of the Corona at Matheson, Colorado, June 8," (Plates XVIII, XIX, and XX), Edison Pettit and Hannah B. Steele; "The William C. Sproul Eclipse Expedition," John A. Miller.

Physical Review, for August; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "On Electromagnetic Induction and Relative Motion. II," S. J. Barnett; "Electronic Frequency and Atomic Number," Paul D. Foote;

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"Some Properties of Metals under the Influence of Alpha Rays," A. C. McGougan; "On the Specific Inductive Capacity of Metals," Fernando Sanford; "Polarization Measurements at Wire Cathodes in Separately Ionized Gases," C. A. Skinner; "Simplified Theory of the Cathode Fall in Gases with Application to Plates and Wires," C. A. Skinner; "The Magnetic Properties of Some Rare Earth Oxides as a Function of the Temperature," E. H. Williams.

Psychological Clinic, for June; *Woodland Avenue and 36th Street, Philadelphia; $1.50 per year, 20 cents a copy:* "Orthogenic Cases XII: Obadiah, a Child with a Numerical Obsession," Sarah W. Parker; "Effects of Smoking on Mental and Motor Efficiency," Oscar J. Johnson, University of Minnesota.

School World, for May; *Macmillan Company, London, England; 7s. 6d. per year:* "Man-Power and the Schools"; "The Cost of Science Teaching in Secondary Schools," Douglas Berridge; "Graphical Interpretation," R. Wyke Bayliss; "A Nature-Study Museum in a Rural School," Ernest R. Beale; "The Welsh University and the Secondary Schools," A. E. L. Hudson, B. A.; "The Position of Science in Schools"; "The Central-School System of London"; "Teachers and the Future of English Elementary Education."

CUT DOWN ON EXPENSE: LIVE THE SIMPLE LIFE.

Here are a few points on thrift given by the British Chancellor of the Exchequer which are worthy of emulation by Americans:

Lives must be lived more simply.

Personal, household, and business expenses must be reduced to the minimum.

Surplus weekly or monthly earnings, over necessary expenditures, must be invested straightway in war securities.

Current balances at the banks should be kept as small as possible and the money invested in war bonds.

Nobody's money can be neutral.

Money lent to the country fights for the country.

Money spent on luxuries and non-essentials is helping the enemy.—[*War Loan Reveille.*

MICA SCHIST FOR FURNACE LINING.

Mica schist is one of the commonest kinds of metamorphic rock and consists essentially of mica and quartz, with which may be associated certain other minerals, such as garnet and staurolite. Owing to its marked foliation, its softness, and its generally unattractive appearance, it has not been greatly used as structural stone or as paving or crushed stone. It was once quarried near Bolton, Conn., for use as flagstone, but it was too soft to withstand the wear upon it in places of much travel.

The mica, to which the softness of mica schist is due, however, successfully withstands a very high temperature, and as the stone can be readily cut into blocks of the desired shape, mica schist has therefore been used considerably as furnace lining. The mica schist quarried for this use is found in eastern Pennsylvania, at places conveniently near the metallurgical plants in which it is required. The quantity of mica schist produced for this purpose in 1917 was 39,975 short tons, an increase of 6,739 tons, or 20 per cent, over 1916, according to statistics compiled by G. F. Loughlin, of the United States Geographical Survey, Department of the Interior. The value of the output in 1917 was $85,986, an increase of $38,682, or nearly 82 per cent. The greater increase in value was due to a rise in price from $1.42 to $2.15 a ton, which largely represents the increased cost of production.

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CLASSROOM SAYINGS.

A virtual image is the reflected image of an object. A real image is the image of the object itself made smaller or larger or changed in some similar way, or the same.

Velocity of light is in an almost instantaneous; in glass it takes longer, for there is more space to travel through, especially in prisms.

A galvanometer is an instrument used to determine whether a body contains electricity or not. (If it does).

The two-fluid voltaic cell does not have so much induction as the one-fluid voltaic cell.

Lightning is caused by the breaking of the electric sound in the clouds. It is a form of electricity. The only protective device which I know anything about is the lightning rod. I have heard that severe weather may make this type unsuccessful.

Draw a line through the point of contact of the two tangent circles exterminating in the circumferences. Equal arcs are sustained by equal chords.

"If one straight line meets another straight line, the sum of the adjacent angles will be equal."

"Side (*a*) is either equal, or it's not equal, or it's greater."

"A polygon is an angle of many sides."

"The dip of the earth is the angle at which the earth slants."

"An electrophorus is the instrument which is used in making electricity."

"Dielectric are electric waves that pass between the molecules as the wind passes through a forest."

"Dielectric is the faculty of not having electricity pass through readily."

"A right angle is an angle of 90° whose sides are equal and which has a common vertex."

CALL TO DUTY.

From the battle fields in France there comes an unspoken call that should find an answer in every American's heart. The recent great events in Europe, the successes of American arms on the fields of France should spur every American to greater effort.

Our people at home should not rest on the laurels of our soldiers in France. Every death on the field of honor in the line of duty and for our country's cause should be a call to us for every sacrifice and every exertion to aid the cause for which our soldiers are fighting, for which our soldiers have died.

Increase production, decrease consumption, save, and lend to the Government. Every cent lent to the United States is used to support, strengthen, and aid our soldiers in France.—[*War Loan Reveille*.

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CENTRAL ASSOCIATION MEMBERS.

2125 Sherman Av., Evanston, Ill., Sept. 20, 1918.

My dear Fellow-Associationer:

Do you have a copyright on your educational knowledge? A few years ago one of the elementary teachers in a small town was talking with her principal about a wonderful grammar outline she had received in a summer course at the Normal School. She was willing that the principal should see it, but "Please don't show it to any of the other teachers for I paid my money for that and it is *mine*."

Happily the Central Association isn't built on that principle. We believe that every teacher should become 100 per cent efficient, and we believe that every member of the Association should help to attain this end.

We take for granted that you are glad to be a member of the Association, that you appreciate the privilege of associating with other progressive teachers at the annual meeting and of crossing intellectual swords with them, that you see in School Science and Mathematics a magazine unique and valuable, and that you appreciate the Proceedings as a concise summary of what transpired at the annual meeting. We also hope you approve of the attempt to make the Association of even wider influence through the Service Department.

This year we feel that a meeting of the Central Association is justified only as it takes account of war conditions and definitely strives to meet the changing conditions due to the World War. The program is based on this. Its central theme is "The Educational Demands of an Awakened Democracy." The committee on "Science and Mathematics in the High School of Tomorrow" expects to present individual reports to the various sections. Our president is emphasizing the importance of stressing this thought in his letters to the chairmen of the different sections.

Now, what are you going to do about it? Are you going to hoard your educational advantages, or are you ready to give the glad tidings to others that you have found a fountain of information and inspiration and want others to know about it? One of the men whom I most respect is the college professor who persuaded me to join certain educational associations.

We want *you* to get *at least* one new member for the Association this year. Bring out your former Proceedings; lend your copies of School Science and Mathematics. When the new programs appear about the first of November they will be first class advertising material. Use them. If a teacher says he cannot attend the meeting, remind him he is all the more in need of the printed reports of the meeting and of the monthly magazine.

Remember it is the *personal touch* that wins, and we want to double our membership through *you*. Lend a hand.

Sincerely yours,

CHARLES S. WINSLOW,
Chairman Membership Committee.

PRODUCTION OF FELDSPAR IN 1917.

The production of feldspar in the United States in 1917 amounted to 126,715 long tons of crude material, valued at $474,767. Eight states—North Carolina, Maine, Maryland, New York, Connecticut, Pennsylvania, California, and New Hampshire, named in order of magnitude of their production—contributed to this, the largest output ever recorded, it being 4 per cent, 42 per cent, and 7 per cent greater in quantity than the amounts for 1914, 1915, and 1916, respectively.

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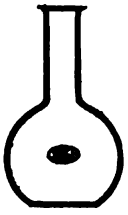
A NEW CHEMICAL CATALOG 94

A Laboratory Hand Book



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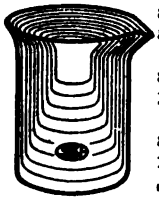

A WORD ABOUT GLASSWARE.

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A BRIEF BIBLIOGRAPHY ON GAS WARFARE.

By B. J. Rivett,

Detroit Northwestern High School.

At present there is a great deal of interest in the subject of gas warfare, and it is especially important that the chemistry teacher be informed as to the composition of the gases and preventive measures used. Until recently there has been little literature available, but within the past three months several authoritative articles have been published. Probably the two most interesting discussions are those of Dean H. P. Talbot of the Massachusetts Institute of Technology and Major S. J. M. Auld of the British Military Mission. Any person interested in chemistry will be amply repaid by reading the books or any of the articles in the periodicals. The following is the list:

Atlantic Monthly, August, 1918—"Chemistry at the Front," by H. P. Talbot.

Scientific American Supplement, March 2, 1918—"Methods of Gas Warfare," by Major S. J. M. Auld.

World's Work, August, 1918—"German Liquid Fire," by Major S. J. M. Auld.

Saturday Evening Post, May 25, June 1, June 8, and July 6, 1918—Articles by Major S. J. M. Auld.

Scribner's Magazine, June, 1918—"Gas Attack," by Emmanuel Bourcier.

Journal of Laboratory and Chemical Medicine, October, 1917.

The book, *Manual of Gas Attack and Defense*, by Major William Kirby, published by Edwin N. Appleton, Broadway, New York City.

The book, *Trench Fighting*, by Captain F. H. Elliott, published by Houghton, Mifflin & Company, Boston.

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WHAT WAR DOLLARS DO!

The attention of owners of Liberty Bonds is called to the following. They are financing the work:

On one day in June approximately 27,000,000 cartridges of various descriptions were produced in the United States manufacturing plants for the United States Government.

The daily average production of United States Army rifles was broken in the week ending June 29, an average of 10,142 rifles a day of a modified Enfield and Springfield type being maintained. In addition spare parts equivalent to several thousand rifles and several thousand Russian rifles were manufactured.

The Ordnance Department has produced 2,014,815,584 cartridges, 1,886,769 rifles, and 82,540 machine guns since the United States entered the war. The daily output of cartridges is now 15,000,000.—[*War Loan Reveille.*

BOOKS RECEIVED.

A Calendar of Leading Experiments, by William S. Franklin and Barry MacNutt. Pages viii+210. 15×22 cm. Cloth, 1918. $2.50. Franklin, MacNutt & Charles, Publishers, South Bethlehem, Pa.

Palladin's Plant Physiology. Translation. Edited by B. E. Livingston. Pages xxv+320. 15.5×23 cm. Cloth. 1918. P. Blakiston's Son & Company, Philadelphia.

The Anatomy of Woody Plants, Y. E. C. Jeffrey. Pages x+478. 15.5 ×23 cm. Cloth. 1917. University of Chicago Press.

Plant Genetics, by J. M. Coulter, University of Chicago, and M. C. Coulter. Pages ix+214. 13.5×19.5 cm. Cloth. 1918. University of Chicago Press.

Junior High School Mathematics, Books II and III, by George Wentworth, David E. Smith, and Joseph C. Brown.

Book II, pages vi+250. 13.5×19 cm. Cloth. 1918. 76 cents. Book III, pages vi+282. 13.5×19 cm. Cloth. 1918. 96 cents. Ginn & Company, Boston.

Elementary General Science, by Daniel R. Hodgdon, Normal School, Newark. Pages xxii+553. 15×20.5 cm. Cloth. 1918. $1.50. Hinds, Hayden & Eldredge, New York City.

Elements of General Science, Revised Edition, by Otis W. Caldwell, Teachers College, Columbia University, and William L. Eikenberry, University of Kansas. Pages xii+404. 13.5×20 cm. Cloth. 1918. Ginn & Company, Chicago.

The Main Currents of Zoology, by William A. Lacy, Northwestern University. Pages vii+216. 13×19 cm. Cloth. 1918. $1.35. Henry Holt & Company, New York City.

Industrial Arithmetic for Girls, by Nelson L. Roray, Dickinson High School, Jersey City. Pages viii+196. 12.5×19 cm. Cloth. 1917. 75 cents net. P. Blakiston's Son & Company, Philadelphia.

Economy in Food, by Mabel T. Wellman, Indiana University. 36 pages, 13×19 cm. Cloth. 1918. 30 cents net. Little, Brown & Company, Boston.

Second Course in Algebra, by Herbert E. Hawkes, Columbia University, William A. Loby, Kansas City Polytechnic Institute, and Frank C. Touton, Central High School, St. Joseph, Mo. Pages vii+277. 13×19 cm. Cloth. 1918. $1.00. Ginn & Company, Boston.

General Science Manual by Leland R. Thompson. High School, East Chicago, Indiana. 101 experiments. 21x27 cm. Cloth covers. Atkinson, Mentzer and Co., Chicago.

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William Lewis Eikenberry, University of Kansas.

Recent important scientific discoveries are responsible for this revised edition of GENERAL SCIENCE. It follows the same excellent style and form which made the first edition so widely popular. In addition, there has been a thorough rewriting of the text; new chapters have been added on electricity; a set of important application problems for each chapter, and much new material on household industries and art. xii+404 pages, illustrated, $1.28.

CIVIC BIOLOGY

By Clifton F. Hodge, the University of Oregon, and
Jean Dawson, Board of Health, Cleveland.

As its title indicates, the purpose of this book is to present a thorough explanation of all the biological forces, both helpful and injurious, that profoundly affect community life. It shows clearly how by united effort the undesirable elements can be discouraged or exterminated, and how the beneficial can be fostered and preserved. 381 pages, fully illustrated, $1.60.

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A NEW SERVICE DEPARTMENT.

The Central Association of Science and Mathematics Teachers is inaugurating a new department—the Service Department. It has always been the aim of the Association to render service to its members through its meetings, its magazine, and its printed *Proceedings*, but it desires to be of even greater service in the realm of science and mathematics to the individual teacher.

Purpose.

The purpose underlying the inauguration of this new department is to give the individual teacher, wherever he may be, assistance in solving his problems. D. A. Lehman of Goshen College, Goshen, Ind., Corresponding Secretary of the Association, is the secretary of this Service Department. All inquiries received by him will be referred for answer to various teachers prominent in their lines of work.

Suggested Lines of Inquiry.

Supplies.—Latest or most efficient apparatus for demonstrating certain problems; special reference books; lists of publications by United States Government; names of reliable supply houses.

Professional Development.—Information and advice concerning summer courses, requirements for admission into various school systems (procedure necessary, type of examination, etc.), efficiency measurement cards, vocational guidance.

Problems.—Information upon matters involving reference work in Chicago libraries. Solution of practical classroom problems and teachers' "troubles."

Motto.—"The Association Lives to Serve."

Address, D. A. Lehman, Goshen College, Goshen, Ind.

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BOOK REVIEWS.

A Calendar of Leading Experiments, by William S. Franklin and Barry MacNutt. Pages viii+210. 15×22 cm. Cloth. 1918. $2.50. Franklin, MacNutt & Charles, South Bethlehem, Pa.

A book equally as interesting to the physics layman as to the physics teacher. It is written in the author's characteristic style. They see the fun and humor of teaching as well as the serious phase. It will surely arrest and hold the student's attention and thus secure the results to be sought. The book has fundamentally to do with classroom experiments, those being selected which have a suggestive and investigational nature rather than those which give nothing but information. It is refreshing to get hold of a book which actually does break away from formalism and invites the student into the confidence of the instructor.

C. H. S.

Plane Trigonometry, with tables, by Eugene H. Barker, Head of Department of Mathematics, Polytechnic High School, Los Angeles, Cal. Pages 172. 16x24 cm. 1918. $1.00. P. Blakiston's Son & Co., Philadelphia.

In accordance with the author's belief he has emphasized the following: a thorough familiarity with trigonometric functionality, acquaintance with the inter-dependence of the functions, a knowledge of the methods of trigonometric analysis, power of initiative in the development of formulas, and a certain definite resolute skill in their application to the solution of practical problems. These things are presented and discussed in a direct and understandable fashion, while the pure mathematics side of the subject is largely omitted. The student is shown how to put his computations in compact form, and to check his results. The figures are well drawn and the pages present an inviting appearance.

H. E. C.

Logarithms and Anti-Logarithms, by C. H. Forsyth, Ph. D., Instructor in Mathematics in the University of Michigan. Pages 45. 15.5x23.5 cm. 1915. 75 cents. George Wahr, Ann Arbor, Mich.

The tables include five-place logarithms of numbers, five-place numbers to logarithms, the first seven powers of numbers to 100, and squares of numbers to 1000.

H. E. C.

Advanced Algebra, by W. C. Brenke, Professor of Mathematics in the University of Nebraska. Pages 196. 14x21 cm. $1.25. 1917. The Century Co., New York.

This text contains for the most part the material of the chapters on algebra in the author's *Advanced Algebra and Trigonometry.* Some matter has been added, some has been omitted, while the form of presentation has been altered in a number of places, exercises changed, and all the figures have been redrawn. The usual topics of the course in college algebra are covered with a well-arranged review of elementary algebra. Numerous simple applications are given in the exercises and problems. Graphic methods and logarithms are introduced early and used in the solution of problems throughout the book. These things, in addition to well-selected material and clear presentation of theory, should make it a very satisfactory textbook.

H. E. C.

Plane and Spherical Trigonometry, with tables, by W. C. Brenke, Professor of Mathematics in the University of Nebraska. Pages vi+121+39. 14×21 cm. 1917. $1.25. The Century Co., New York.

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By EUGENE HENRY BARKER, Head of Department of Mathematics, Polytechnic High School, Los Angeles, California. 86 illustrations. 8 vo. vii+172 pages. Cloth $1.00, postpaid.

P. Blakiston's Son & Co., Publishers Philadelphia

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This book contains in revised form and with some additions the material of the author's textbook, *Advanced Algebra and Trigonometry*. The illustrations are instructive, and a large amount of graphic work is given in the exercises throughout the book. While all the topics and methods of trigonometry as a mere tool for the practical man are included, there is also some excellent work in vectors, harmonic analysis, trigonometric equations, complex numbers, and hyperbolic functions that the technical student really needs. The plan of giving answers to odd-numbered exercises only is good. A cardboard protractor, in degrees and radians, is provided in a pocket inside the book cover. In addition to tables of logarithms are natural functions, conversion tables, degrees to radians and, conversely, mathematical constants, log x to base e, e^x and e^{-x}, and squares, cubes, square and cube roots.

H. E. C.

Junior High School Mathematics, Second Course, by William L. Vosburg, Head of Department of Mathematics, The Boston Normal School, and Frederick W. Gentleman, Junior Master, Department of Mathematics, The Mechanic Arts High School, Boston. Pages x+212. 13×19 cm. 1918. 90 cents. The Macmillan Company, New York.

This *Second Course* aims to bring the pupil who leaves school at the end of his eighth school year in contact with adult activities that require some knowledge of mathematics, and to aid the pupil who continues in school in deciding whether or not he is capable of continuing his work in mathematics with profit. It includes arithmetic of the home, farm, and city, mensuration, and linear equations. Those who are interested in the newer phases of junior high school mathematics will find it worth while to examine the two books in this series.

H. E. C.

The Course in Science, Vol. V, Francis W. Parker School Year Book. 168 pages. 64 illustrations. Francis W. Parker School, Chicago.

The *Year Book* presents the science work as taught in this school, throughout both the elementary and high school grades. It represents a distinct step towards a new and improved school curriculum, and is the result of a number of years of independent, experimental, and developmental work on the part of many members of the faculty.

It has not been written by a few in authority, with the expectation that other teachers will slavishly follow it, but as an attempt to improve the choice of materials, to suggest better methods of presentation, and to unify the science instruction of the school.

Following a presentation of the general principles underlying the organization of the course, the detailed outlines are given grade by grade and course by course, showing how all the work in science may be based upon the interests, activities, and problems of the pupil. Not only is the course given in outline, but the outcome is indicated by many examples of the pupil's work, as shown by their own papers, or as given in morning exercises. The experimental work is fully presented, together with many references for class reading or as aids to the teacher.

The book is well illustrated, and should be of interest to all teachers in the elementary school, to high school teachers of science, and to principals and superintendents interested in the making of a vital school curriculum based upon the interests and activities of the children.

R. W. O.

Infinitesimal Calculus, Section II, by F. S. Carey, Professor in the University of Liverpool. Pages x+352. 14.5×22.5 cm. 1918. $3.00. Longman, Green and Co., New York.

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The topics covered in this section include exponential and hyperbolic functions, motion of a particle along an axis, definite integrals, arc formulas, partial differentiation, double integration, expansion in power series, curve tracing, envelopes, evolutes, roulettes, differential equations, graphics, and nomography. While much space is given to the development and discussion of principles and formulas there are many applications in geometry, physics, and mechanics. Students in calculus will find these two sections of *Infinitesimal Calculus* of value as books of reference.

H. E. C.

Predetermination of Prices, by Frederic A. Parkhurst, M. E., Organizing Engineer. Pages viii+96. 15×23 cm. 1916. $1.25. John Wiley & Sons, Inc., New York.

In this book the author presents an argument on the possibilities of predetermining true costs, basing it on his own experience and the results of his methods during several years. The first chapters emphasize the fact that true costs cannot be obtained at any time unless all methods incidental to processing are under absolute control. The last chapter discusses the possible ideal, which can be attained through the science of management. The methods used are made plain by a large number of diagrams and illustrations of order forms, work order forms, time cards, and cost sheets.

H. E. C.

Scientific Method in the Reconstruction of Ninth-Grade Mathematics, by Harold O. Rugg, Associate Professor of Education in the School of Education, University of Chicago, and John R. Clark, Chairman, Department of Mathematics, Parker High School, Chicago. Pages vi+190. 17×24 cm. Paper. 1918. $1.00. The University of Chicago Press.

During the ten or fifteen years that secondary mathematics has been under fire of friend and foe, various methods of investigation have been used and various correctives have been proposed. On the one hand we have the manner of procedure of a few authoritative specialists who arrive at conclusions through reflective assurance; and of superintendents and supervisors of schools who assign instruction in mathematics to teachers on the basis of convenience and saving of expense with little regard to their qualifications and abilities. In either case, possible questionnaires are sent out, hurried investigations are made, and then comes the grand pronunciamento, the teaching of mathematics in our high schools is a failure, let it be abolished.

In marked contrast to this procedure we have in this monograph a report of a long-continued and well-planned study of the fundamental causes of the inefficiency of mathematics teaching, and a well-founded program for reconstructing ninth-grade mathematics. Above all it is an earnest call to teachers and supervisors of mathematical instruction throughout the country to coöperate in making such a program effective. What has been done by the authors and what can be done by teachers to aid in this work is clearly set forth in the following topics: an inventory of the material of the present course in algebra, how algebra became the ninth-grade course, the design and construction of standardized tests and what they reveal, development of abilities through drill, training in "logical thinking," curriculum-making in secondary mathematics, experimental teaching, and a program for the reconstruction of ninth-grade mathematics.

H. E. C.

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NOVEMBER, 1918

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

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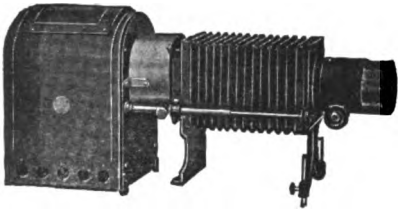

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 8 NOVEMBER, 1918 WHOLE No. 154

SOME GROUP THEORY.

BY G. A. MILLER,

University of Illinois, Urbana.

In their report entitled "Training of Teachers of Elementary and Secondary Mathematics" a subcommittee of the International Commission on the Teaching of Mathematics named the following nine subjects as those which may later be expected to be involved in the preparation in pure mathematics of the prospective mathematics teacher: Calculus, differential equations, solid analytic geometry, projective geometry, theory of equations, theory of functions, theory of curves and surfaces, theory of numbers, and some group theory. The natural significance of the adjective *some* in connection with the last of these nine subjects would seem to be that the knowledge of the prospective teacher along the line of group theory need not be as thorough as that along the other lines named, but that he should know something about this subject.

It is evident that strictly speaking, the adjective *some* should have modified each of the other subjects named above, since no one can know *all* about any one of the broad fields covered by them, but the common usage of these terms seems to justify the conclusion that what is meant is that the prospective teacher should have a good course, or its equivalent, in each of these broad fields of pure mathematics, except possibly the last one. In regard to this field it might be sufficient if he had listened to a course of lectures devoted to it or had looked over some of the literature relating thereto.

Two questions naturally present themselves in this connection. The first of these is, Why should the teachers of elementary and secondary mathematics be expected to know anything about group theory? If good reasons exist for demanding such a knowledge, it is natural to ask, Why is a superficial knowledge in this field less objectionable than in the other fields noted above?

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The former of these questions could scarcely embarrass anyone who possesses at least a slight knowledge of the modern literature on elementary and secondary mathematics. When one reads that such fundamental notions of geometry as point, line, and plane can be based upon group notions, and "that the idea of displacement, and consequently the idea of group, has played a preponderant part in the genesis of geometry"[1] one can easily see why teachers of elementary geometry should know *some* group theory.

The teachers of elementary arithmetic and elementary algebra may have less conscious need of a knowledge of group theory than those of elementary geometry, but the former are likely to read about the groups and subgroups formed by certain sets of real or complex numbers with respect to multiplication, and the groups and subgroups formed by other sets of such numbers with respect to addition. Moreover, the group properties of the n roots of unity may easily present themselves to such teachers as soon as they think just a little beyond what they are actually expected to teach.

Having established the fact that the teachers of elementary and secondary mathematics must know something about group theory in order to understand some of the best modern literature relating to the subjects which they are expected to teach, it remains to answer the second of the two questions raised above. Since there is an algebraic group theory, an analysis group theory and a geometry group theory, one might perhaps infer that the use of the adjective *some* in the list of subjects mentioned in the first paragraph of this article might have been due to a feeling that the subject of group theory was too broad to come within the mathematical purview of the prospective teacher, and that such a student should therefore confine his attention either to a special part of this subject or to a somewhat superficial survey of the whole field.

It is, however, less interesting to consider the possible reasons for the use of the adjective *some* in the given connection than to inquire what elements of group theory are of most importance to the prospective mathematics teacher. It might be supposed that these elements should include only one definition of the word group as a technical mathematical term. Since various writers use this term with different meanings, the reader who has only a single definition in mind is likely to be embarrassed there-

[1] H. Poincare, *The Monist*, vol. 9 (1899), p. 32.

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by and hence one definition of this term, may be worse than none. Perhaps the most important idea for the student to acquire early in regard to group theory is that *there is not only one definition of the mathematical term group* but there are several, and there is not only one group theory but there are several such theories.

How then can we know that a certain set of operators constitutes a group? With respect to a finite set there is little trouble, since all the definitions of finite discontinuous groups which are found in good modern literature are practically equivalent. This is, however, not the case as regards the definitions (explicit or implied) of an infinite group. In fact, such a standard work as the *Encyklopädie der Mathematischen Wissenschaften* contains on page 218 of Volume I a definition which is satisfied by the infinite set of numbers of the form.

$$\frac{2^q}{q} \text{ being any natural number,}$$

when these numbers are combined by multiplication. It is evident that this set of operators does not involve the identity, since 0 is not a natural number, nor does it involve the inverse of any of its operators.[2] If we would let q assume also the value 0, the set would include the identity but not the inverse of any of its other operators.

The most comprehensive definition of the technical term group is found on page 243 of tome I, volume 2, of the *Encyclopédie des Sciences Mathématiques*.[3] It is as follows: "One says of an aggregate of objects that it forms a group in the most general sense of the word, when there is given a rule permitting to deduce from any two A and B of the objects of the aggregate a third object C of this same aggregate." It is evident that this definition of group does not imply the existence of an identity or of the inverse of an operator in the aggregate under consideration. In fact, the aggregate may contain various identities and various inverses of the same operator and still satisfy this definition of a group as results directly from the consideration of algebraic number fields, which are included under the term group in both the German and the French editions of the large mathematical encyclopedia.

One frequently finds in recent mathematical literature criticisms relating to the use of the term group with respect to a

[2] A. Loewy, *Archiv der Mathematik und Physik*, vol. 9 (1905), p. 105.
[3] A similar definition appears in tome 3, volume 1, page 334, of this work.

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set of operators which are said not to form a group by the authors of these criticisms. For instance, A. Loewy criticizes, in the article to which we referred, the definition of the term group as given in the large German mathematical encyclopedia, stating that it is necessary to add another condition in order to obtain a definition of an infinite group. On the other hand, the conditions imposed in the said encyclopedia definition are already much more restrictive than those imposed in the definition cited in the preceding paragraph and they include the latter. Hence it is clear that this particular criticism by an eminent authority is based on the assumption that such a definition as the one cited in the preceding paragraph is too general.

We refer to this matter in order to emphasize the fact that what appeared to many as an illegitimate use of the term group due to carelessness or ignorance has been legalized in recent years. The technical term group has thus been given a breadth of meaning comparable to that given to the term function in 1837 by a definition due to Dirichlet. This breadth of meaning is, however, not new but it embodies the fundamental notion which guided the earliest investigators in this field and to which certain explicit restrictions were added by later writers with a view to definite progress in certain directions.

Such restrictions remain desirable and will doubtless be continued, but instead of saying they are imposed on *all* groups we should say that they are imposed on the particular groups under consideration. Thus there arises the desirability of further classification of groups, and the study of groups in which the inverses of the operators are not present or in which a linear equation may have more than one solution. Up to the present it has been customary to study only those groups in which the inverse of each operator is present and in which a linear equation has only one solution. On the other hand, an equation of higher than the first degree can have more group elements for roots than the degree of this equation. These groups have been divided into four great classes named as follows: Finite, infinite discontinuous, finite continuous and infinite continuous.

The most important property of groups is the existence of *subgroups*, and hence subgroups should be considered immediately after some of the definitions of groups have been examined and illustrated. In particular, the facts that the order of a subgroup divides the order of the group whenever this order is finite, and that an invariant subgroup corresponds to the identity

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of an isomorphic quotient group are of fundamental importance and should be included in the briefest course along this line. The subgroups of the continuous groups of movements of space corresponding to points and to lines respectively, are also of fundamental importance.

An important notion which is intimately connected with group theory but which is not confined to this subject is that of *isomorphism*. The special isomorphism in which there is a (1,1) correspondence between the elements of two groups is particularly important since it enables us to study once for all the fundamental properties of large categories of groups, and since it gave rise to the notion of abstract groups. Moreover, the possible isomorphisms of a group with itself are of fundamental importance in some of the applications of these groups. Hence the question of isomorphisms might well be considered immediately after that of subgroups, even if a thorough study of this question cannot be taken up until after a considerable body of theorems relating to group properties has been established.

The most important continuous group is composed of the transformations under which the properties of figures studied in elementary geometry are invariant. This group consists of movements, reflections, and similarity transformations and was called by F. Klein the *principal* or *fundamental group*. Two of its most important subgroups were noted above. It is interesting to note, in particular, that the dimensions of space are invariant under this group. As an instance of a group, in the most general sense, under whose transformations the dimensions of space are not invariant we may refer to the following:

$$x' = ax+by$$
$$y' = akx+bky$$

which clearly transforms all points of the plane into those of a line passing through the origin, if we regard a and b as parameters and k as a constant.

The most important finite group is the cyclic group and there is one and only one such abstract group of each order. The cyclic group of order n is perhaps best known in the form of the n nth roots of unity. Among non-cyclic groups of finite order the dihedral groups, or groups of the regular polygons, are perhaps the most important. It must, however, be admitted that it is difficult to decide which are the most important among the hosts of finite and infinite groups intimately related with questions of elementary mathematics. Moreover, groups are social

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entities and can be studied better in connection with their social environment than by isolation.

Enough may have been said to show that the suggestion that prospective teachers of elementary and secondary mathematics should know *some* group theory cannot reasonably be assumed to imply that this subject is less intimately related to their teaching than any of the other eight subjects named above. Nor should it be assumed that the study of this subject normally belongs at the end of the teacher's preparation in pure mathematics. In fact, *some* group theory should come early among the courses which follow a first course in calculus, and later studies in mathematics should be illuminated by the group concept. The main reason why students often find the study of group theory difficult is that it is usually taken up late in their course and then developed from a very abstract point of view.

Groups are intrinsically a part of our natural mathematical endowment and the group concept should be nurtured in our early mathematical development by directing attention to group properties appearing in elementary geometry and in elementary arithmetic. On the contrary, this concept is allowed to famish while other mathematical concepts are nurtured, and then when late in the student's course he turns back to it for light towards the solution of some of his most difficult problems, he naturally finds a weakling whose normal development would demand more time than he feels that he can then give to it. Total starvation is the natural consequence.

BLACK WALNUT WANTED.

The virtue of the black walnut has been its own undoing. Because it does not readily warp or split, it is the best of all woods for airplane propellers and gunstocks, and the Government finds that the demand greatly exceeds the supply. An appeal, therefore, is being made to all owners of walnut, to assist in getting every available log to market. County agents and boy scouts are being pressed into service for locating walnut trees, and everybody interested in winning the war is urged to report the existence of available material. The logs wanted are at least twelve inches in diameter at the small end and eight or more feet long. The Government does not buy this timber but will put owners in touch with manufacturers who are using it. The price at present is about $90 a thousand feet. A tree that will square twelve inches and make a log sixteen feet long is therefore worth nearly $20. We are frequently told that certain products are scarce because of the war, and this is likely to be true of walnuts for some time to come.—[*American Botanist.*

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MR. DOOLEY, 2D, ON THE DISCUSSION METHOD.

(With Apologies to the Original Mr. Dooley.)

By Jean Broadhurst,

Teachers College, Columbia University.

Ye' see, Michael, me b'y, since me faythe settled so manny questions av internashunal dispute, it cum to me natshral loike to be inthrusted in the prisint day and its problims. And me posishun av windy washin' at collige is furtherin' me in the way av it, for windy washin' is a quiet job and slow, as is well known. So I hear manny a thing that me puir faythe missed altogither. And the quarest av thim all is the way thim big perfessors is a tryin' to git shut av their jobs, entoirely.

Do ye iver hear me, Michael, a sayin' that the windys don't need washin' or cud wash thimsilves? Be gorrah, a man 'ud be two fules in wan, he wud, to do that—for he'd sure lose his job altogither and the windys wudn't be washed at all, at all.

But this discussin method is a quare one. As I kin make it out, it's a way the perfessors have av lettin' the scholars run on by thimsilves loike a horse widout anny driver at all. No, it's not loike Murphy it is, fur his old white horse stops at ivry house and waits till Murphy gives the baby his bit av pasteurized milk for the day, and comes out wid the empties. That's not loike the discussin way at all, for old Murphy knows where his horse is ivry minute and where he's goin', and what's more, the old horse fetches up at the *right* places ivry time. But in the discussin way, a horse ud av to av the wings av a bird and legs av a kangrue, for he'd av to jump from one street to anuther and skip whole blocks intoirely; and to kape up wid him Murphy wud av need av an aeroplane wid all the accelirators and patent brakes that av yit to be invinted. Besides, Murphy's horse niver goes backward, me b'y. He's a wise old horse, and *he'd* know it av he did.

Now, as I kin make it out, in the discussin way the perfessor starts 'em on a little way wid his highbrow stuff, and thin he drops the lines intoirely. And ivry horse pulls a different way, zigzaggin' around as if the royal road to learnin' was the Abbey Inn hill for the steepness av it.

And thin, whin thim as don't discuss, the passingers, so to speak, have been yanked this way and that till they don't know which way they're goin', sumthin' breaks, and the hull thing stops, wid each av thim discussers in a diffrunt place; and the passingers begin wanderin' about aimless-like, some av thim

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evin goin' back where they started at the fut av the hill and not knowin' it at all, and thinkin' they're goin' ahead, bedad.

It's all true. They're befuddled as no whisky cud do it in so short a time evin in this prohibishun town. But the perfessor, ye say. Well, it depinds on the perfessor. There's nothin' harder to ketch than a horse broke loose, but some av thim perfessors kin do it. Some av thim let the discussers tire thimselves out, and some av thim ketches and houlds thim by feedin', a scatterin' the grain around. A handful av wheat goes a long way, if you mix it wid chaff, me b'y. But some av thim perfessors'll be caught by the pure food laws yit. There's only wan thing that's saved thim so far—that their stuff ain't done in packidges! There's no label to say what's chaff, but the adultration's somethin grand. It'd make anyone av thim rich, if it was gasoline or evin sugar he was by the way av dealin' in.

No, it's a quare way to me way av thinkin'. The perfessor starts 'em off a discussin' by telling 'em a little av what he knows, the straight stuff, and thin the discussers break in to tell about what they don't know about. They actually git up and say, "I've niver had any experience in this field, but some years ago, I"—would ye believe it! And often and often agin they say, "I am unable to offer anything in the direct line av this discussin," and thin talk for twinty minutes!

But I'm thinkin', some av the perfessors av caught onto the way to stop it. For some av thim begin, "This mornin' we will discuss the educashun av the child from the standpoint av—" ye can't expect me to remimber the rist av it—and thin talk *thimsilves* till the bell rings! They're the wise guys, they be, for *they* git sumthin' done. Thin iverbody's more satisfied, fur the classes thinks they've been discussin', which flatters the edicated mind, and they've learned sumthin', too, which ain't so common in the rale discussin way.

And the worst av it is it's a spilin' the schools, too. Me little Jimmie is a bein' learned the same way. The taycher starts out to learn thim that Connecticut raises tobaccy and the kids wid opporchunities or imaginashuns get up and say, "When I was to me grannie's in Maryland I seen fields and fields of tobaccy"; and "Me uncle owns two tobaccy farms in Kentucky"; and "When we go on our vacashun in our motor car, maybe we'll go to Connecticut and see thim tobaccy fields."

Why can't they "believe the painter" whin the taycher tells thim it grows in Connecticut widout all this introducshun? And

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they discuss, too, just like the grown ups, wid the taycher leadin' thim on, wid "Why is Connecticut a tobacco state?" And they guess all the raysons they can think of—the ones they had for corn and watches and firearms and shoes till somebody strikes the one the taycher knows about. And thin they start over agin a keepin' the smart Alecky ones a talkin' all the time; and the kids don't hear no good grammar day in an' out wid the glib ones a gettin' glibber and the slow ones overworked sortin' out which is talk and which is learnin'.

And all this discussin' and spreadin' thimsilves out thin spoils thim fur rale work, I'm thinkin'. There's some classes in collige the discussers niver take—or if they do, they drop it afore the day av reckonin', the examinashun, so to speak.

Why, there was wan wuman discusser—there's comparative few faymale discussers, but some av thim's as bad as the men—who got into a reg'lar class 'stead av a discussin one. She'd been fed up on discussin where it's "all a matter av opinion anyhow," as one perfesser always says glib-like when the discussers get too hot and nobudy'll give an inch—and so she'd cum to where she cudn't settle down to learn annythin' for hersilf or by hersilf, as Abraham Lincoln said. And wan day, whin she'd been partic'lar stoopid, she jest pushed her glasses and spiders back, and said, lofty-like, "I don't approve av this way av studyin' at all. I don't want to *see* that a spider's got six legs. In Perfessor Black's class we'd *discuss* it." But the bug perfessor just said, "If the Lord's kindly left you the *wan* sinse of eyesight, that's wan av the manny things you *can't* discuss wid his *eight* legs stickin' right out in plain sight."

Manny's the time a discusser has interrupted a flow av rale knowludge, that'd make ye thrill, evin wid your feet the other side av the windy in the ice and snow, and I'll hear the passingers, as we called thim, heave a sigh as the same old discussers git up and say nuthin' at all. It's always the same discussers, about five or six to a class, maybe. And if they *av* to git what they don't know out av their system, you'd think they'd put thim discussers all in a class by thimsilves, where they cud waste their own time and let the rist av the class go on widout all this zigzaggin' round. But the perfessor is so busy holdin' fast to his lead-horse lines that he don't hear thim sighin' on the back seats. I expect the perfessors cum from the city and don't know about horses as we do, me b'y. For it ain't the prancin' leaders that really pulls the tally-ho, is it? And for all their

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cavortin', the coach keeps to the same old road just the same. So their leadin', evin, ain't much to brag av. And did ye iver see a tally-ho team doin' anny rale work—and neither will you, me b'y. All ye kin say is they're havin' a good toime av it, but it's the hefty Percheruns ye see t' the coal wagons.

Some day the remarks av thim back seats'll git louder. They're a gittin' perty well bumped around, thim passingers, and they don't loike it. And the day av reckonin' is comin' whin they'll rise up and demand their rights, and we'll live to see it, be gorrah, fur it's cummin' soon.

Who knows but the Collige'll have guards to kape out thim discussers. There'll be me opporchunity, for I kin spot a discusser ivery toime. Fur what I've suffered from some av thim discussers, evin on the windy sills, which is remote, so to speak, wud make me the best bouncer on the force, and widout anny eye to the Carnegie medals, either.

And it'll cum, for this discussion way ain't what some av these perfessors think it is. For it's only a few that do the *discussin'* and whin they start, the majority begins a *cussin'*. And it's the majority that rules in this free country av America, praise be, except in prisidintial elections, av course.

RAINFALL AND GUNFIRE.

It is, of course, impossible to ascertain definitely whether bombardment can produce rain or not, because one cannot determine in any specific case what the rainfall would have been in the absence of bombardment. But there is a very widespread notion that gunfire may exercise an influence on the weather and there is always some one to seize upon any opportunity to show a possible connection between them. Since the experiments of C. T. R. Wilson showed that ions may act as nuclei for the condensation of water vapor, a new explanation has been put forward by several persons who claim that condensation may occur as a result of ionization of the air caused by bombardment.

As a matter of fact, Wilson has shown that in order for the ions to be effective in producing condensation a "fourfold" degree of supersaturation is required for the negative ions, and a considerably higher degree for the positive. Others have shown that supersaturation is impossible so long as there are any particles of dust in the air. Dust is always found in the air, even in samples taken from the tops of high mountains far from towns. Consequently, we cannot suppose that ions are the immediate cause of any condensation produced by bombardment.

No rational account of any complete process by which gunfire could affect the weather has ever been put forward. Nor does the statistical evidence that is available support the proposition. It shows, rather, that the condition of the weather is a factor in determining the time of battles. An examination of the rainfall in France since the commencement of the war shows no outstanding features which could not be accounted for by the pressure distribution existing at the times of the individual falls.

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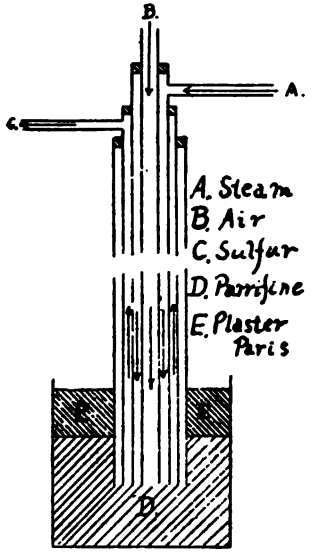
A SULFUR WELL.

By Robert M. Ladd,
High School, Gary, Indiana.

Until recently the world has relied on Sicily for its supply of sulfur. Some years ago a great bed of this material was found to underly a large part of the states of Louisiana and Texas, but it lay beneath a bed of quicksand, which made it inaccessible by the ordinary means. For years it was untouched because no one could figure out a practical method of bringing it to the surface. Finally an American chemist developed a plan by which it could be melted in the deposit and forced to the surface as a liquid. A six inch cased well is driven. Inside of the casing three concentric tubes are placed. Steam under a pressure of 100 pounds is forced down one of these. Its temperature is about 160°C. As sulfur melts at 114°C., the mineral is liquefied. Hot compressed air is forced down through another of the pipes and the molten sulfur comes to the surface in the third.



I have found it somewhat difficult to make this process clear to my classes, so I have arranged a demonstration which is illustrated in the accompanying drawing. Because I had no way of generating my steam at any great pressure, I substituted paraffine for the sulfur.

Using this simple demonstration, I find that it is not difficult to make clear the process to even my sixth grade classes.

The apparatus was constructed of glass tubes of four different sizes. Side arms were sealed to each of the two tubes of intermediate size. The upper end of each of the three larger tubes was closed with a paraffined cork. I used an ordinary Florence flask as a steam generator. The compressed air was supplied by the foot bellows of our blast lamp. It was warmed before passing into the well.

The paraffine was melted and cast in a large beaker. The casing was sunk in this and then the paraffine was covered with about an inch and a half of plaster of Paris. This was to prevent the escape of the steam and the melted paraffine around the sides of the well.

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RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,

University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

ON THEORIES CONCERNING SOILS AS MEDIA FOR PLANT GROWTH.[1]

By Chas. B. Lipman,

University of California, Berkeley.

In my humble opinion, one of the common and fortunate characteristics of thinking men is their propensity to theorize. Assuming that, it is but natural that, in the course of human experience, so vital a topic as the soil and its relations to plant growth should not have been overlooked in the making of man's theories. From early times in human history, there have descended records of direct or implied speculation on the mystery of the developing plant in its cycle from seed to seed. Thus we find in the very early records of the ancients the writings on agriculture of Hesiod, and the far more extensive writings of Mago, the Carthaginian general. These were employed by Virgil as a basis for the beautiful poetry of his youth, entitled the Georgics, to which I shall make brief reference again. Other famous writings on agriculture in ancient times, which included the prominent speculations of the day concerning plant growth, were the celebrated treatises of Cato, of Varro, and of Columella. Insofar as the art of husbandry is concerned, it is striking to note that the ancients were nearly as fully informed as we are today. Parenthetically, I may say that perhaps it would be more accurate, in one sense, to say "equally informed," rather than "fully informed." Of the truth of this, we have ample evidence in the writings to which I have just referred. We may take as an example the work of Virgil.

The pastoral scenes of ancient Italy, amid which one of the greatest of classic poets was reared, seem to have been replete with evidences of farming technique similar to our own. Moreover, there appears to have been known to Virgil many a tradition respecting agriculture which remains unchanged to this day in most farming communities. Indeed, there seems to be little in our farming methods which was not also known to Virgil,

[1]Read before Sigma Xi, April 24, 1918.

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though we think now that we can, in a few cases, give better reasons for our procedures than could the ancients for theirs. I say better, advisedly, because most practices on our farms today are based on empirical tests which are far from being above question, even though they have been studied considerably. In the beautiful lines of the Georgics, we find exhortations on deep plowing, on fallowing, on timeliness of tillage, on the choice of heavy and light soils for certain groups of crops, respectively, and on many other phases of the subject of soil management, as well as on many other agricultural subjects. But even this keen observer, who sang the praises of the humble art of husbandry, was, like all other mortals, prone to theorize. For example, he connects the best times for tillage with the blowing of certain winds, and the presence of snakes in certain lands with the infertility of the latter. Thus, early in man's thought on soils and their productiveness do we have records of his speculations and theories. Such theories, it must be added, however, were arrived at by the deductive, rather than by the inductive method which we employ and which offers a more rational and more secure basis for the formulation of theory.

So far from improving on the ideas of the ancients, the writers of the Middle Ages actually detracted from their value by a relapse into greater superstition and less reason, and agriculture suffered with general culture from a lack, not only of attention, but of careful reasoning, of the making of rational theories, and of attempting to prove them. Those who would satisfy themselves with regard to the agricultural theory and practice of the Middle Ages, such as it was, are referred to August Meitzen's large tomes on the development of rural settlements and of agricultural practices among the Germanic peoples.

We are obliged, therefore, to continue the narrative on the history of soil fertility theory by bridging the large gap between the end of the era of the ancients and the end of the sixteenth century. At this point we begin to see attempts on the part of thinkers to give the reasons for the well-known effects of certain farm practices. One of such early attempts, extraordinary for its keen insight, was the statement cited by E. J. Russell from Palissy, a French thinker. This statement, made in 1563, puts forward the idea that manures have for their function the return to the soil of something which has been removed from it by plants; further, that all plants contain some kind of salt and that such salts are found in the ash of plants when the latter are

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burned. Palissy, therefore, promulgated the hypothesis that the burning of straw in wheat fields returns essential salts to the soil from which they came, hence maintaining its productiveness. He finds in this idea the reason for what he believes to be the success of the burning of straw and stubble by grain farmers. While in our modern conceptions of the functions of organic and inorganic manures in soils there is no necessary confirmation of Palissy's speculations, the latter are at least rational and, in part, doubtless in accord with our important facts. The most remarkable feature of the theory, however, is that it is so very far ahead of its time. About two and one-half centuries were to elapse before so generally sound a hypothesis (in our view) could be fully appreciated and proved. Meanwhile, there was no lack of attempts, often resulting in a relapse into mediaeval vagueness, to account for the ever fascinating mystery of the plant. Whether such attempts are truly to be regarded as relapses and retrogressions or are to be accounted for by the lack of facilities for the dissemination of such speculations as Palissy's, cannot now be definitely ascertained. To assume the strong probability of the latter view, however, appears to be reasonable.

Whatever the cause of such apparent retrogression may have been, we find a considerable number of attempts in the two centuries following Palissy's utterance to find or to guess at the supposed "principle" of vegetation. Most prominent among such attempts is the celebrated experiment of Van Helmont, carried out toward the middle of the seventeenth century. This experiment, though much quoted by all writers on subjects involving plant growth, may perhaps be unknown to many of you and hence I beg the indulgence of the rest for presenting it now. Two hundred pounds of oven-dried soil were placed in an earthen vessel and moistened with water, and a willow shoot weighing five pounds was properly planted in it. The soil was protected against dust and wind by a perforated sheet of iron. Whenever necessary, rain water or distilled water was added to the soil to maintain optimum moisture conditions. Exactly five years after the experiment was started, Van Helmont found that the tree which had grown in that period from the willow shoot weighed about 169 pounds and 3 ounces. The soil was then again weighed and found to have lost about two ounces. Van Helmont therefore concluded that a little over 164 pounds in weight of wood, bark, and root (the leaves had not been collected and weighed as they fell) were built up of water, since nothing

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else had been added to the soil during the period of the experiment. This famous experiment is of the greatest value to us, both because it illustrates admirably the seventeenth century theory with regard to soils and plants, and because it serves as an excellent example of the ease with which it is possible to draw erroneous conclusions from sound experiments. If Van Helmont had not disregarded the small but essential loss of two ounces from the soil, if he had thought of the part that the air might play in plant growth, he would not have concluded from the simple experiment just cited, as he did, that water is the "principle" of vegetation. The celebrated scientist, Robert Boyle, in his book entitled the "Sceptical Chymist," published in 1661, accepted Van Helmont's conclusion after having repeated the experiment with another plant and obtained similar results. Boyle went farther by distilling and analyzing his plants and obtained from them salt, spirit, earth, and oil. He could not resist the conclusion, therefore, that these substances must be produced from water in the process of the plant's growth. Again, therefore, a scientific man of high standing, and one to whom chemistry and physics owe much, fell a victim to a system of ratiocination which failed to take into account certain essential factors in the life of plants.

Johann Glauber, another celebrated chemist of the time, formulated a new hypothesis. This consisted of the theory that saltpeter or nitre is the "principle" of vegetation. Glauber's hypothesis was based on two observations: One that saltpeter was obtained from earth from cattle sheds; the other that applications of nitre to the soil gave astounding increases in the growth of plants. Since the earth in cattle sheds was affected by the urine and the droppings of the animals, Glauber assumed that the saltpeter was contained in them and was derived in turn from the plants which were eaten by the animals. In Glauber's view, therefore, the question of the fertility of soil resolved itself into one of supplying the necessary nitrates, and the value of various organic matters consisted in their properties of yielding nitrates to the soil. In the case of this hypothesis, it will be noted that both air and water seem to have been disregarded, other chemical substances ignored, and the fact that soils untreated with manure or urine might also contain nitrates seems not even to have been surmised; if it had been, Glauber's hypothesis might never have been made, or, at least, it would have been much modified.

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Other theories of a similar nature to those of Van Helmont and of Glauber were not wanting at this period. Kulbel regarded humus as the source of a mysterious something which was the principle of vegetation. Another distinguished chemist, Boerhaave, in a textbook on chemistry, modified somewhat Glauber's view and stated his belief that a complex juice, "the chyle of the plant," toward which the animal, plant, and mineral kingdoms all contributed, constituted in the soil the principle of vegetation. All of these theories possess in common, however, the characteristic belief in one substance as the principle of vegetation, and the utter disregard of the factor of other variables than the one which they recognized as possibly being of some importance.

A somewhat different view and attitude on this subject was introduced, however, in the third decade of the eighteenth century by Jethro Tull. Tull was a man of an inventive turn of mind, who possessed very definite ideas and entirely unique ones with respect to the nutrition of plants. He was the inventor of the seed drill and the horse cultivator and published a book in 1730 entitled "Horse Hoeing Husbandry." His interesting, and to us now risible, theory was that plants utilized the fine particles of soil as food directly, provided only they were fine enough. These very fine particles constituted, in Tull's own picturesque language, "the proper pabulum" of plants and were ingested by the swelling of the roots following moisture absorption, and through the pressure thus exerted forcing the particles into certain hypothetical "lacteal mouths of the roots." With this view on the nutrition of plants as a basis, Tull urged most emphatically the importance of constant tillage, whereby he believed it possible to reduce the sizes of the individual soil particles to a point which would permit of their absorption into the circulatory system of the plant as just described. As a corollary to his theory, Tull expressed his belief on the incorrectness of the view that different plants require different soils and that if given a thoroughly tilled soil, any of them will do well on any soil and will absorb any kind of substances presented to the roots; also that the fining of the soil aided in its absorption of certain gases from the atmosphere which he considered in some mysterious manner as being "nutritious." In general, Tull's ideas on plant nutrition are expressed in the following words from his own pen: "It is agreed that all the following materials contribute in some manner to the increase of plants, but it is disputed which of them is that very increase or food: (1) nitre,

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(2) water, (3) air, (4) fire, (5) earth." The strikingly novel feature of Tull's hypothesis, therefore, inheres in his consideration of the soil particles as constituting the food of plants. Aside from that idea, he seems to have been troubled about finding some one thing of those just mentioned which was responsible for plant growth and thus did not differ essentially from his contemporaries or predecessors.

In the four decades following the appearance of Jethro Tull's interesting book, no theories were put forward either in England or on the continent which constituted distinct steps forward in the solution of the problem of plant growth as viewed today. To be sure, that period differed from the foregoing in that experiments came into vogue and attempts were made to determine the composition of the plant by such methods as were then available and to account for the effects of salts, alkalies, and other materials, when applied to soils. The outstanding work of that period is probably that of Francis Home, published in 1756, and entitled "The Principles of Agriculture and Vegetation," written as a result of experimental work which Home started at the solicitation of the Edinburgh Society. In this period, too, the hypothesis of Külbel, or a form of it, to the effect that humus is the source of food for plants, was revived by Wallerius and is of interest here mainly because such revival served to perpetuate the idea on the continent of Europe, at least to some extent, until Liebig's day. The humus theory was indeed no improvement on much earlier statements such as those of Lemery, who wrote in that vain on nitrification and on certain phases of plant nutrition as early as 1717. The state of relative stagnation of soil theory, which characterized the period under consideration, viz., that between 1730 and 1770, is merely a reflection of the status of science in general at that time. In certain of the works on chemistry of the day, we find ample evidence of a vagueness and a crudity of conception on relatively simple matters, which are astounding to us and which constitute evidence of the dazzling progress achieved by the science of chemistry since then—a space of about one century and a half only. As an instance of the kind of conceptions which were not merely current in those days, but considered most advanced, permit me to cite a statement concerning nitric acid, extracted from Crell's "Die Neuesten Entdeckungen in der Chemie," published about 1767. Crell says:

"Chemists differ as to the origin and essential constituents of

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nitric acid. Some regard it as a peculiar body floating in the air and following the north and west winds; some as a product of decay; some believe that it originates from common salt; and the majority and most up to date regard it as derived from carbonic acid gas, which is a spirit of vitriol."

This state of knowledge, or lack of it, on the continent is further attested by the fact that the Berlin Academy of Sciences awarded a prize to a chemist by the name of Pietsch, who proved, as he thought, that saltpeter is not a salt and that "nitric acid consists of a fine fatty substance or combustible."

Small wonder, then, that little progress was made in soil theory during the period in question. With progress in chemistry and in physics wanting, the intellectual impetus to and sinews for a better understanding of the plant organism and the soil was also lacking. But a new era of thought was ushered in, in about the year 1770. In England, at least, but also in Switzerland and Holland, a new generation of chemists was beginning to make an impression through its advanced thinking and experimenting, and through its overwhelmingly important discoveries. Thus Priestly, Scheele, Ingen-Housz, Senébier, and de Saussure are names to conjure with in any generation of scientists. This was a generation of investigators who appeared to see the hopelessness of working on problems with many variables, who appreciated the inadequacy of the all-inclusive and yet impotent theories of Tull, Külbel, Lemery, Wallerius, and Berzelius, and who, therefore, attempted to take one step at a time in studying the mystery of plant nutrition. In 1771, Priestley attempted to determine what effect, if any, plants exerted on air vitiated by such phenomena as combustion, putrefaction, or animal respiration. He used sprigs of mint and found that air like that described could be purified by that plant. From this fact he concluded, erroneously, however, that the process of respiration in plants was essentially different from that in animals, the first being such as to purify and the second such as to vitiate air. This work preceded Priestley's discovery of oxygen and, therefore, lacked a certain definiteness and precision which it would doubtless have had otherwise. That was not the only reason for the erroneous conclusion, however, since Priestley persisted in it even after he had discovered oxygen, because he failed to take into account the effect of light on the power of plants to affect the condition of the atmosphere. The difference of opinion arising between Priestley and Scheele, who insisted that

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plants, like animals, vitiated the air, remained for Ingen-Housz to reconcile. He showed that both Priestley and Scheele were right, that purification of air by plants goes on in light only, while vitiation of air by them goes on in darkness. It was thus demonstrated that the plant had a definite effect on the atmosphere and a great step was taken in the progress of plant physiology. In 1782, Jean Senébier not only confirmed the findings of Ingen-Housz, but also carried out investigations on the reciprocal problem of the effect of the atmosphere on the plant. As a result of these studies, he attributed the weight of the willow tree in Van Helmont's experiment to what he called "l'air fixe." We find thus the first rational view on the rôle of the atmosphere in plant life in the experiments and discussions of Senébier. With the exception of the studies of de Saussure, which I shall allude to presently, there is probably nothing of such towering proportions in the progress of plant physiology, considering the radical departure which it represented from the views of the foregoing ages, as the group of researches to which I have so briefly referred as beginning with Priestley and culminating with the brilliant discoveries of Senébier. They were all characterized by a freshness, a simplicity, and a directness which, in the midst of such dominating crudities as those which I have cited in the chemistry of their day, makes them stand out with a boldness and isolation which not only mark the beginning of a new and progressive era, but which typify the results of great thought and great achievement, stimulated by the unusual imaginations of all time.

A period covering nearly a quarter of a century was to elapse, however, before further progress, with Senébier's striking and important discoveries as a basis, was made. It appears that that was not a period of inactivity so much as one of preparation. The satisfactory corroboration of Senébier's explanations on the relations of plant and air required more than the mere continuation of his tests, which were largely qualitative in nature. The progress of the subject then required recourse to the quantitative method, which still remained to be developed. This was forthcoming, however, in the work of Theodore de Saussure, and proved the latter to be a man of surpassing genius and industry, and insured for him a place of distinction in the most exclusive "hall of fame" which the annals of science have established for all ages. It appears from Senébier's statements that de Saussure's father was well acquainted with the work of the former and hence

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we have the probable reason for Theodore de Saussure's study in a quantitative manner, among other things, of the relation of plant to air, which absorbed the interest of Senébier. Employing methods of astounding simplicity and precision, considering the state of knowledge of the day, de Saussure demonstrated the existence of plant respiration. He showed by careful eudiometric measurements the amounts of oxygen which plants absorb and the quantities of carbon dioxide which are evolved. He established the fact that carbon dioxide is decomposed by plants in the presence of light, with the resulting evolution of oxygen. He, therefore, made it perfectly clear that carbon dioxide in small quantities in the atmosphere was indispensable to plants, that it furnishes them with carbon and with some oxygen, that water is decomposed by plants and employed with carbon in the synthesis of carbohydrates.

But de Saussure further showed by quantitative measurements that nearly all of the dry weight of plant substance is obtained from the air, that only a very small part comes from the soil, but that nevertheless that small part is absolutely essential to the life of the plant. He argued, moreover, from the results of his experiments, against such ideas as those of Tull anent the inability of plant roots to select certain constituents from the medium in which they grow and to leave others untouched. Thus, he believed that membranes of root cells permit water to pass through more readily than salts and hence tend to cause increased concentrations of the medium surrounding them; also that they permit different salts to enter with different degrees of facility. He studied the composition of plant ash and demonstrated that it varies with the nature of the soil and with the age of the plant, and that it consists largely of the alkalies and phosphates. He pointed out the fallacy of the ideas of Kirwan and Lampadius, promulgated as late as 1796, that plants produce potash and silica, by showing that plants grown in water show no gain in ash, and that there is just as much found at the end of the growing period as is contained in the original seed and no more. Last, but not least, de Saussure demonstrated that the small portion of the dry matter of the plant which comes from the soil supplies nitrogen, which is essential to plants and which cannot be assimilated by the latter directly from the air. This idea should be noted particularly, since it was not adhered to by de Saussure's distinguished successor, Liebig, and was the cause of a controversy which was not ended until past the middle of the last century, when it was decided in favor of de Saussure's view.

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All of this work was done in the most careful manner, every step in progress was checked, and no superfluous steps were taken. The beautiful simplicity of de Saussure's account of all this work entitled "Recherches Chimiques Sur la Vegetation" and published in Paris in 1804 cannot be overemphasized. In a small duodecimo volume of 327 pages and a few plates, he sets forth with clearness and brilliance all the essentials of the vital subject of plant nutrition in much the same form as we accept them today. To a student of de Saussure's clear, concise, and experimentally supported statements, the work appeals as would a Velasquez or a Titian to an art lover. One can see in it the bold and effective stroke of the master hand impelled by the master mind, and the color of the artist finds its analogy in the penetrating logic and ingenious experiment of the scientist. De Saussure painted with a large brush on a gigantic canvas.

The remarkably lucid and amply supported statements of de Saussure were, however, largely disregarded in Europe and particularly on the continent. The old humus theory was still in vogue and was, partly or wholly, supported by such eminent scientists as Sir Humphry Davy and Berzelius, the former writing it into his textbook on agricultural chemistry nearly a decade after the appearance of de Saussure's little volume. So far from adding to de Saussure's splendid contribution, many of the writers of the day, then, denied the truth of some of the most fundamental ideas so carefully and laboriously established and so clearly and simply propounded by de Saussure. In the decade between 1830 and 1840, considerable work of interest was being done, for example, the work of Sprengel on the ash constituents of plants, the work of Schübler on soil physics, the excellent quantitative work of Boussignault in field experiments, and the work of Liebig in agricultural chemistry. Only the last named deserves attention in connection with soil theory, however, since none of the others changed fundamentally de Saussure's conceptions with regard to the soil as a medium for plant growth and particularly on the subject of plant nutrition. The work of Liebig, however, deserves special consideration, not because he added much that was new, for he actually added little that was fundamentally different from de Saussure's teaching and in fact attempted to change some of the latter to their detriment, but because of the position which history has accorded him and because he succeeded in elaborating and making men generally accept the discoveries of de Saussure.

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At the request of the British Association, Liebig made a report on the state of organic chemistry. This celebrated document was published in 1840, under the title "Chemistry in its Application to Agriculture and Physiology." In this book, which quickly went through several editions, Liebig took to task the chemists and physiologists of the day for the crudity of their ideas in the light of de Saussure's discoveries over a generation before. He attacked and completely demolished the humus theory, though it appears to me that his claims as to the general acceptance of that theory in those days were much exaggerated, to judge particularly from the literature of British scientists of the day. He defined more sharply than de Saussure had done some of the more detailed phases of the functions of the mineral elements in plant growth. He gave a detailed account of the respiration process in plants and of his ideas on the fixation of carbon and hydrogen. He put forward the hypothesis that roots of plants excrete acetic acid, which serves to dissolve the minerals of the soil and thus to render available elements essential to plant growth. He set forth the unequal solubilities of the compounds in soils. He believed that plants will absorb all constituents of solutions readily and will excrete such as are not necessary in their growth, and that they obtained their nitrogen from the ammonia of the air.

As can readily be seen, these were, more strictly speaking, amplifications and elaborations of the earlier ideas than new ideas in themselves. Indeed, a number of them have since been proved to be partially or wholly incorrect, but these will be considered later. It is most striking in Liebig's work to note the poignant sarcasm by which he awakened the scientific world to a realization of its backwardness, by which he forced it to examine existing ideas critically and to accept only such as were in accord with outstanding facts and the soundest theories. As characteristic, it may be interesting to quote Liebig's manner of accounting for the non-acceptance in full of the theories and experiments of de Saussure and his supporters. He says:

"All this is due to two causes which we shall now consider.

"One is that in botany the talent and labor of inquirers has been wholly spent in the examination of form and structure: chemistry and physics have not been allowed to sit in council upon the explanation of the most simple processes; their experiences and their laws have not been employed through the most powerful means of help in the acquirement of true knowledge. They have not been used because their study has been neglected.

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"All discoveries in physics and in chemistry, all explanations of chemists, must remain without fruit and useless because even to the great leaders in physiology"—and he might have added in chemistry—"carbonic acid, ammonia, acids, and bases are sounds without meaning, words without sense, terms of an unknown language, which awaken no thoughts and no associations. They treat these sciences like the vulgar who despise a foreign literature in exact proportion to their ignorance of it, since even when they have had some acquaintance with them, they have not understood their spirit and application.

"Physiologists reject the aid of chemistry in their inquiry into the secrets of vitality, although it alone could guide them in the true path; they reject chemistry, because in its pursuit of knowledge, it destroys the subjects of its investigation; but they forget that the knife of the anatomist must dismember the body, and destroy its organs, if an account is to be given of their form, structure, and functions. . . .

"The second cause of the incredulity with which physiologists view the theory of nutrition of plants by carbonic acid of the atmosphere is that the art of experimenting is not known in physiology, it being an art which can be learned accurately only in the chemical laboratory. . . ."

It is not surprising that such statements aroused the slumbering spirits of the doubly conservative physiologists and chemists of Liebig's time. In later editions of his book he formulated two so-called laws: first, the Mineral Law—"the crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure"; and, second, the Law of the Minimum—"by the deficiency or absence of one necessary constituent, all the others being present, the soil is rendered barren for all these crops to the life of which that one constituent is indispensable."

As time went on, moreover, Liebig came to believe more and more firmly in two theories: first, that the needs of crops for minerals are indicated by the composition of the ash, and second, that plants can obtain from the air the nitrogen which they need. He believed that the latter idea was borne out by the longevity of certain Dutch, Hungarian, and American soils, and further that on the basis of these two ideas we should merely have to analyze the plant ash and the soil, and draw up certain tables for use by the average farmer with regard to the fertilizer needs of his crops and soils in the form of minerals only.

(*Continued in December.*)

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BOLSHEVIK MULTIPLICATION.

By H. J. R. Twigg.

Certain South Russian peasants are able to multiply together figures no matter how large, and yet do so while *unable to do anything more than double, halve, add, or subtract*, and not understanding fractions; any such arising have to be ignored. The *modus operandi* is as shown in four examples:

No. 1. Multiply (say) 40×25:

(i) Put 40 at the top of the left-hand column (or *vice versa*).
(ii) Put 25 at the top of the right-hand column to match.
(iii) Go on halving the left hand.
(iv) Go on doubling the right hand.

Ignore left hand. Total up right hand (*except* where left-hand figures are even).

L.		R.
~~40~~	.....	~~25~~
~~20~~	.....	~~50~~
~~10~~	.....	~~100~~
5	.....	200
~~2~~	.....	~~400~~
1	.....	800
		1000

No. 2. Say 28×10:

L.		R.	
~~28~~	.....	~~10~~	Not added, 28 even
~~14~~	.....	~~20~~	Not added, 14 even
7	.....	40	½ of 7 = 3½. The ½ ignored
3	.....	80	½ of 3 = 1½. The ½ ignored
1	.....	160	
		280	

No. 3. Say 9×6:

L.		R.	
9	.....	6	½ of 9 = 4½. The ½ ignored
~~4~~	.....	~~12~~	(4 is even)
~~2~~	.....	~~24~~	(2 is even)
1	.....	48	
		54	

No. 4. Say 28×19:

L.		R.
~~28~~	.....	~~19~~
~~14~~	.....	~~38~~
7	.....	76
3	.....	152
1	.....	304
		532

Correct every time!

Can any readers of *School Science and Mathematics* explain the principle involved in these operations or throw any light upon its origin?—[School *World*.

LOAN $7,097,000,000 TO ALLIES.

Up to date the United States has loaned the allies $7,097,000,000, of which $6,377,787,895 has been expended in this country in purchasing their obligations for munitions, food, etc. The allies still have a large balance to their credit in the treasury.

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A NEW METHOD OF MAPPING COMPLEX GEOGRAPHICAL FEATURES, ILLUSTRATED BY SOME MAPS OF GEORGIA.

By Roland M. Harper,
College Point, N. Y.

Ever since geography became a subject for scientific investigation it has been the aim of geographers to represent the various complex features of the earth's surface, such as topography, soil, climate, vegetation, population, agriculture, etc., on maps in as rational and obvious a manner as possible. When each of these features is resolved into its components it is a simple matter for anyone who has the necessary data to map one component at a time, in a manner which may require some skill but leaves little room for difference of opinion; and if they do not conflict too much two or more components may be put on the same map.

For example, altitude, the principal component of topography, is easily represented by contour lines. Soils may be mapped according to the percentage of some one physical or chemical constituent, such as fine sand or silt, or calcium or phosphorus. Innumerable climatic factors, such as temperature and rainfall (average, maximum, minimum, seasonal, departure from normal, etc.), length of growing season, and average date of arrival of spring, are easily mapped, singly or two or three together. (The daily weather maps with which we are all familiar show temperature, barometric pressure, and one or two other things.) In mapping vegetation we may indicate the distribution of one species at a time, by means of dots, boundary lines, or shading, or we may map several species at once if they do not overlap too much. We might also indicate the percentage of evergreens, or of plants belonging to a given family, in each state or county or natural region, by appropriate shading. Under the head of population we can indicate density by dots or otherwise, and rate of increase in a given period, proportion of negroes, foreigners, tenants, etc., by shading.

But routine work of the kinds mentioned is mere cartography, or chorology, rather than true geography, and can be undertaken just as well by topographers, climatologists, botanists, demographers, etc., as by geographers. Furthermore, if we mapped only one thing at a time we would need innumerable maps to show all the geographical features of any region, and they would fail to give the user a good mental picture of the region. The geographer therefore seeks to put as many things

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as possible on one map; but not everything, for that would be simply chaos. This calls for considerable skill in generalization, and often some artistic talent besides, as for example in making topography more legible to untrained persons by using hachuring instead of contours.

Climate and population are so complex that it would probably be impossible to put all the features of either one on one map and still have it intelligible. In mapping crops the principal difficulty is one of generalization. On a map of sufficiently large scale one could show every field with its particular crop, but on the scales ordinarily used that would be out of the question, and one would have to resort to some such expedient as determining the leading crop in each area, and mapping a corn region, a wheat region, a cotton region, etc. In mapping soils and vegetation one would have the same difficulty, plus the much greater one of deciding just where to draw the line between different types, which might intergrade in all sorts of ways. Detailed soil maps of several hundred counties have been published by the U. S. Bureau of Soils, and one needs only to compare the maps of neighboring or similar counties made several years apart, or by different men, to see how much individual judgment may vary in classifying the soils. The few soil maps of the whole United States that have been published (see for example those in Bulletins 85 and 96 of the Bureau of Soils) are primarily soil province maps, based on geology, topography, etc., and tell very little about the soils themselves. Pretty good vegetation maps have been made of some small areas, but all the existing ones of whole states and larger areas are far from perfect. (The latest of North America is that of Harshberger in his *Phytogeographic Survey of North America*, 1911[1], and the latest of the United States is that of Shreve in the *Geographical Review* for February, 1917.[2])

The writer has gradually evolved (but cannot say perfected) a method of mapping soils, vegetation, crops, and some other complex features, which though it involves no radical innovations is probably an improvement on any now in use. It does not fulfill the ideal of putting everything on one map, but it shows at a glance the prevailing type of soil, forest, etc., in the areas mapped, and has the special advantage of leaving very little to individual judgment after the facts are gathered in

[1]Reviewed in *Bull. Am. Geog. Soc.*, 45:38-42, January, 1913.
[2]Reviewed in *Torreya*, 17:103-106, June, 1917.

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sufficient detail and the regional boundaries located. It might be called the quantitative regional method.

The first aim of the geographer in studying any considerable part of the earth's surface, such as a state or country, should be to subdivide it into areas as homogeneous as possible, to give a *maximum of contrast* between neighboring divisions and require the least possible repetition in describing them. Just how finely one should subdivide is largely a matter of judgment and expediency and the scale used. Small areas are generally more homogeneous than large ones, but if we make them too small they will also be too numerous and too much alike. The boundary between any two neighboring regions should correspond with a comparatively abrupt change in one or more geographical features, whether topography, soil, vegetation, or something else. Of course in many cases we can find no sharp boundary between regions that are obviously different on the whole (especially if the principal difference is a climatic one), and must draw the lines more or less arbitrarily. Again there may be differences of opinion as to what sort of differences should be taken into consideration, what are major and minor regions, etc. But these difficulties are nothing new to scientists, being inherent in taxonomy. They have been met thousands of times in classifying geological formations, minerals, soils, plants, animals, etc., and some have been settled while others are still in dispute.

There have been many attempts to map the geographical divisions of North America or the United States, some of which suffer from the narrow point of view of the author, who may be primarily a physiographer, climatologist, botanist, or demographer, rather than an all-round geographer.[3] But plants are not classified by their leaves, flowers, or fruits alone, or animals by their skeletons or teeth alone, but all possible characters are taken into consideration, as should be done likewise with geographical divisions. A geographical map based primarily on topography (like Fenneman's) does very well in parts of the country where there is considerable relief, but in the coastal plain we often find regions much alike in topography differing considerably in soil and therefore in vegetation and agricultural features, if not also in density and composition of population.

But taking for granted that our geographical boundaries

[3]Several of the attempts to subdivide North America have been summarized by Joerg in the fourth volume of the *Annals of the Association of American Geographers* (1915). The latest on the geography of the United States is by Fenneman in the sixth volume of the same (1917).

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have been agreed upon, we now come to the main issue, of mapping the complex features of each region. The method is simply to take one group of features at a time, that can be measured in the same units, compute statistics for one region at a time, and put the different features in each class on the map *in order of abundance or importance*, indicating them by words of symbols, and using percentages if possible and desirable. For example, soils are divided into types and measured by acres or square miles, vegetation is divided into species and measured in feet of timber or tons of hay, and crops may be measured by either acreage or value.

For many regions in the United States we now have enough Government soil surveys to be fairly representative, and in all but a few of the earliest ones (published about the beginning of this century) the area of each type of soil is given, so that we can add up all the stony clays, fine, sandy loams, etc., and determine the percentage of each. The errors of judgment mentioned a few pages back are just as likely to be in one direction as in another, so that they tend to neutralize each other when several reports on different parts of the same region are available.

For vegetation we have very few reliable quantitative data as yet, except for a few small areas; but the writer by traveling through every known natural division of the southeastern states, by rail or on foot, or both, and jotting down the name of every plant recognized as often as possible, and consolidating the returns afterward, has determined the approximate relative abundance of all the commoner and more conspicuous plants, particularly trees, in that part of the country, and has made a beginning in a few of the northern states.

For crop statistics we have to depend chiefly on Government census reports, which are not altogether satisfactory. Considerable information is given about the yields of different crops in every county, but they are not reduced to a common unit; cotton, for example, being returned in acres and bales, and apples in trees and bushels. Again, pumpkins, watermelons, cabbages, tomatoes, onions, lettuce, and many other things are lumped together under the head of "vegetables." For the whole states the crops are subdivided more minutely in the general volume on agriculture, of the last census, but not in the state supplements; and state statistics are of little use to geographers, for every state in the Union has at least two natural divisions, and

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some as many as twenty. There is, however, a way of circumventing some of these difficulties. In each state supplement the total value of each kind of crop (except where different things are lumped together as above indicated) is given, and by dividing this by the number of acres, bales, pounds, or bushels we can get the average value per unit for that state, which we may assume without serious error to be the same for every subdivision of the state. This gives us a means of reducing the county crop statistics to a common unit. Although value varies considerably at different times and places, it is a better criterion for comparison than acreage, for an acre of strawberries or lettuce, for instance, is worth far more than an acre of corn or wheat, because it requires so much more labor for planting, harvesting, etc.

Some of the states gather agricultural statistics of their own which are more complete than the Government statistics, but this does not happen to be the case with Georgia, the one selected for illustration. The crop statistics published biennially by the Florida Agricultural Department give the value of every important crop (separating all the different vegetables) in every county, and these were used by the writer a few years ago in determining the principal crops in all parts of northern Florida.

In putting these features on maps one map should be used for each kind, and the names of as many things as there is room for printed right in the proper spaces, in order to abundance, or area, or value, as the case may be. The differences between any two neighboring regions in that particular are then very evident. Abbreviations or symbols can be used to save space when necessary, and regions too small to put anything in can either be left blank (being of little importance with reference to the whole area mapped), or else their features can be printed out in the margin somewhere and connected with the proper region by a guiding line. As a region which extends through several states but is commonly regarded as a unit (like the Piedmont region and the Appalachian valley) may vary somewhat in different parts, on account of gradations of elevation, climate, or something else, it is well to work out the statistics for each state separately and map them accordingly, to show just what the variations are. Of course the method here described is just as applicable to political divisions as to natural geographi-

[6] See *6th Ann. Rep. Fla. Geol. Surv.*, pp. 188-189, etc. 1914.

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cal divisions, but to use political divisions alone would be unscientific, and would sacrifice the fundamental principle of maximum contrast to expediency. However, where we are not sure of the natural boundaries we may take certain crops of counties for trial, and after computing statistics for them find that shifting a certain county from one region to another gives more contrast, and thus gradually make our regions more nearly natural.

If we had county statistics of manufacturers they could be mapped in the same way as crops, but unfortuntately the Government publishes manufacturing statistics only for states and

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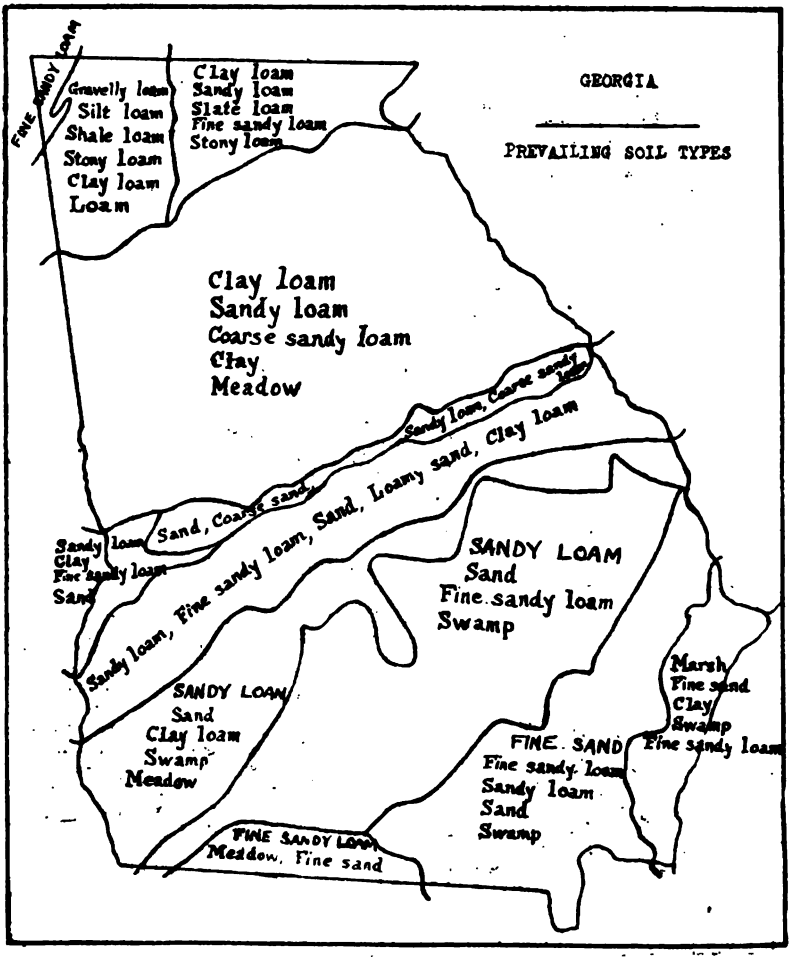
principal cities. Climate and population do not lend themselves well to this sort of treatment, but their salient features for each region might be put on the map in a few words. Topography could be treated statistically, if one wanted to take the trouble to do it, by estimating the area lying between 0 and 100 feet altitude, 100 and 200, etc.; and this was actually done for the whole United States in the tenth census, and correlated with population, etc.

The principles here discussed will now be illustrated by four maps of Georgia. The first shows the names of the twelve subdivisions, the second the soils, the third trees, and the fourth crops. The four northernmost divisions belong to the highlands, and the remainder to the coastal plain. Their boundaries



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are based largely but not entirely on geological formations. On the last three maps the aim has been to list everything that makes up as much as five per cent of the total. Approximate percentages could have been given in every case, but the fundamental data are not yet accurate enough to justify the undertaking. (Perhaps they will be after the next decennial census.) But to give some idea of abundance, wherever an item at the head of a list is believed to constitute over half the total, its name is printed in capitals. (If one had the necessary skill and patience each name could be written in a size proportionate to the abundance of the thing named.) It is useful to bear in mind that the percentages of abundance tend to form a geometrical progression, like the populations of the cities of the United States, arranged in order of size.

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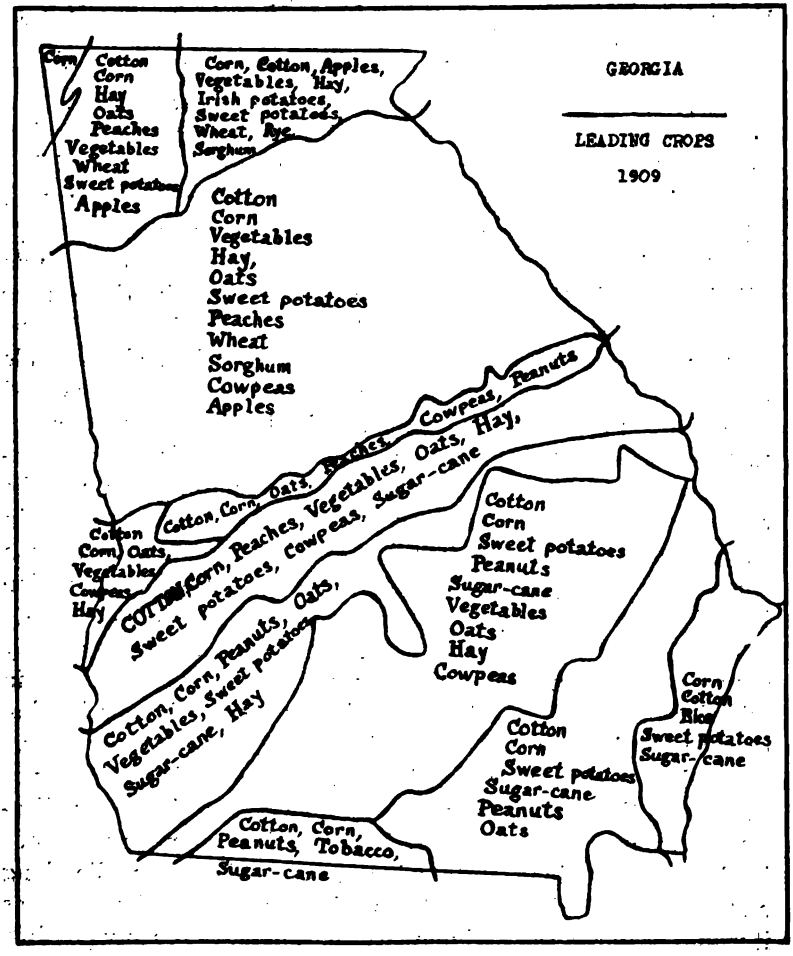
The soil data have been taken from the Government soil surveys published up to the end of 1916, of which there are about forty-two for Georgia. The information about vegetation is based wholly on personal exploration, and covers only the trees, which are the most conspicuous and important part of the vegetation. Technical names are used because they are more definite, the same common name often being applied by the natives in different regions to two or more distinct species of trees. For the benefit of nonbotanical readers a glossary of the names used is appended here. Where only one species of a genus appears on the map the specific name is omitted to save space.


GEORGIA
LEADING CROPS
1909
Corn, Cotton, Apples, Vegetables, Hay, Irish potatoes, Sweet potatoes, Wheat, Rye, Sorghum
Corn Cotton Hay Oats Peaches Vegetables Wheat Sweet potatoes Apples
Cotton Corn Vegetables Hay, Oats Sweet potatoes Peaches Wheat Sorghum Cowpeas Apples
Cowpeas, Peanuts
Cotton, Corn, Oats, Peaches, Vegetables, Oats, Hay, Sugar-cane
Cotton Corn Oats Vegetables Cowpeas Hay
Corn, Peaches, Cowpeas, Sugar-cane
Sweet potatoes
Cotton Corn Sweet potatoes Peanuts Sugar-cane Vegetables Oats Hay Cowpeas
Oats
Cotton, Corn, Peanuts, Sweet potatoes
Vegetables, Sugar-cane, Hay
Corn Cotton Rice Sweet potatoes Sugar-cane
Cotton Corn Sweet potatoes Sugar-cane Peanuts Oats
Cotton, Corn, Peanuts, Tobacco, Sugar-cane

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Acer rubrum. Red maple.
Castanea dentata. Chestnut.
Fagus grandifolia. Beech.
Hicoria alba. Hickory.
Liquidambar Styraciflua. Sweet gum.
Liriodendron Tulipifera. Yellow poplar.
Magnolia glauca. Bay.
Magnolia grandiflora. Magnolia.
Nyssa biflora. Black gum.
Pinus echinata. Short-leaf pine.
Pinus Elliottii. Slash pine.
Pinus glabra. Spruce pine.
Pinus palustris. Long-leaf pine.
Pinus serotina. Black pine.
Pinus Taeda. Short-leaf (or loblolly) pine.
Pinus Virginiana. Spruce (or bastard) pine.
Quercus alba. White oak.
Quercus Catesbaei. (Forked-leaf) Black-jack oak.
Quercus cinerea. Turkey oak.
Quercus coccinea. Spanish oak.
Quercus falcata. Red oak.
Quercus Marylandica. (Round-leaf) Black-jack oak.
Quercus montana. Chestnut oak.
Quercus nigra. Water oak.
Quercus stellata. Post oak.
Quercus Virginiana. Live oak.
Robinia Pseudacacia. Black locust.
Sabal Palmetto. Cabbage palmetto.
Salix nigra. Willow.
Taxodium imbricarium. Pond cypress.
Tsuga Canadensis. Hemlock (or spruce pine).

The crop statistics are taken from the reports of the thirteenth census, and represent relative values for the year 1909. On account of all vegetables except Irish and sweet potatoes being lumped together, "vegetables" have a considerably higher rank than they would if the different kinds were separated. The treatment of hay and forage is almost as unsatisfactory, but that is to a large extent unavoidable. The two kinds (distinct species) of cotton are not separated in the census reports, but the reader can easily remember that all in the southern red hills and north thereof is upland or short-staple cotton, while most of that in the rolling wire-grass country and coastward is sea-island cotton. (If the two kinds were separated corn might outrank either of them in the wire-grass country.) On account of the long time required to add up the crop statistics for every county (there are over fifty counties in the Piedmont region of Georgia alone) and reduce them to a common unit, only a few representative counties in each region have been used for this purpose.

If geographers in other states will use similar methods we may soon have some more satisfactory maps than those current in school geographies, which commonly show only the one leading crop or tree in each state or neighborhood, and that not always correctly. Of course one of the advantages of this method over tabulating the same data on a printed page, namely, the facilitation of comparison between adjacent regions, is not so obvious in the case of a single state, where most of the regions lie along a straight line and can be taken up in a pretty definite order, as it would be in a larger and more complex area, where any possible linear sequence would separate some adjacent regions.

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MATHEMATICS AND EDUCATION.

By L. E. Mensenkamp,
High School, Freeport, Ill.

Most mathematical activity is carried on in connection with educational institutions, and therefore the casual observer might expect to find that the veiws of the mathematics teacher, the educator, and educational administrator were in one accord on questions concerning educational values and the place of mathematics instruction in the curriculum. That such is not the case, however, is a matter of common observation. The educator of today is often rather skeptical of the value of mathematics and is rather inclined to question its right to its traditional place in our educational scheme. He often thinks that it should be replaced by other more "practical" subjects.

One of the causes of this attitude has been the reaction against the doctrine of formal discipline which occurred near the beginning of the twentieth century. There was a time when the main argument in favor of the study of mathematics was the one given by the philosopher, John Locke, which was that it "should be taught to all those who have the time and the opportunity, not so much to make them mathematicians as to make them reasonable creatures, that having got the way of reasoning, which that study necessarily brings the mind to, they might be able to transfer it to other parts of knowledge as they shall have occasion." The present status of this doctrine seems to be somewhat uncertain. There has doubtless been some reaction in its favor, but it is still possible to find among specialists all shades of opinion regarding it. Many elaborate experiments have been made either to verify or disprove it, but often two experts have been unable to agree on the interpretation of the results of the same test. In view of this uncertainty, perhaps the mathematics teacher is wise not to push his claims too far in this direction, especially since there are other good grounds upon which to base claims for his subject.

A second criticism made of mathematics by the educator is that it is abstract and remote from life, and therefore has no place in a scheme of education whose business is to prepare for social efficiency. Efforts have been made to meet this objection during recent years by reorganizing elementary courses in such a way as to defer the more difficult topics to the last part of the course and by introducing applications wherever possible. Here, a difficulty appears. Educators sometimes

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seem to judge the entire utility of algebra for the student by the usefulness and applicability of the problems in the first courses. They seem to forget that beginning students have not at their command a sufficient body of elementary facts from the fields in which mathematics finds its most interesting applications to solve and appreciate problems taken from these fields. The full value of mathematics is not to be estimated from the first-year courses alone, but rather by the use which may be made of it in later work. The mathematicians have, perhaps, been too reticent on the question of applications. They study their subject chiefly because of the aesthetic pleasure which they experience in observing the harmonious relationships of number and form, but they must not forget that outsiders are, in most cases, utilitarians whom it is wisest to meet on their own ground.

The theory of statistics may serve as a bond to bring the mathematician and the educational theorist closer together in the future; it may bring home to the latter something of the practical value of mathematics. The schoolman of today is interested in the objective facts of the educational process; he is trying to found a science based on observation and experiment; he is trying to treat educational problems *quantitatively*. To do this properly, he must borrow tools forged by the mathematician for the treatment and analysis of statistics. For example, it is desirable for him to know the properties of the probability curve, $y = y_0 e^{-ax^2}$. Among other things, he must know the area under all or any portion of this curve. What a world of results from the realm of pure mathematics are implicitly related to this problem—properties of exponential functions, transcendence of e, the properties of infinite series, evaluation of infinite integrals, and so on.

There is a prevailing impression, too, that the applications of mathematics are confined to engineering; so that the prospective engineer is the only person benefited by its study. This idea surely needs correction. Mathematics is coming into wider use in other fields of endeavor every day. In psychology, sociology, and biology, the relations between certain groups of phenomena are being treated by mathematical methods and exhibited by means of correlation-coefficients and correlation-ratios. In economics, Professor Fisher has shown[1] that the general price level, that "high cost of living" which we are all so anxiously interested in these days, is dependent upon five

[1] I. Fisher, *Why the Dollar is Shrinking*, p. 75.

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other variables, and that the relation may be expressed *algebraically* in an equation of exchange. A recent writer on agriculture, at the close of an article dealing with the relations between plant growth and the chemical conditions of the soil, and involving some mathematics, remarks significantly, "It seems a far cry from the logarithmic curve expressing an absorption isotherm to the management of barley and turnips, but the relation is really simple and direct . . . ."[2] Illustrations like these might easily be multiplied.

But it is not sufficient that mathematics *is* useful; that usefulness must be made known to the public. The mathematics teacher of today must be a propagandist; he must use every legitimate means to bring the importance of mathematics to those outside of the schools, so that they may better appreciate the worth of the enterprises upon which he is engaged. In the classroom, let him do as much as the immaturity of his audience will permit to suggest the human significance of mathematics. More than this, he should miss no opportunity to cultivate an appreciation of his subject on the part of those whose opinions direct school policies. The speeches which high school teachers are often called upon to make at gatherings of parents and teachers offer opportunities along this line.

The teacher should also see that the public library in his community is equipped with at least a few good mathematical books. Strange to say, there are libraries in cities of populations of thirty or forty thousands of people which are entirely without books on mathematics. After the books are in the library, he must do what he can to influence people of the right kind to read them. In these and other ways which will readily suggest themselves, the aggressive teacher can help to bring about a situation in which mathematics will be regarded with the respect which it so justly deserves.

[2] E. J. Russell, "*Principles of Crop Production*" in *The Scientific American Supplement* for July 8, 1916.

WHAT THE WAR COSTS.

On July 1 last, the first day of the present fiscal year, the war was costing:

$18,000,000,000 a year.
$50,000,000 a day.
$2,000,000 an hour.
$33,000 a minute.
$555.00 a second.

On July 1 next, according to latest estimates by the War Department, the war, for the twelve months, will have cost $31,000,000,000.

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SUGGESTIONS CONCERNING SCIENCE NOTEBOOKS IN THE HIGH SCHOOL.

By John L. Dahl,
High School, Highland Park, Mich.

The science notebook in the high school is a perpetual problem to the teacher. The solution of the problem should not be neglected simply because the notebook may be considered a matter of little consequence. The science teacher must realize, and must make his pupils realize, that in high school science work there is a great opportunity for developing orderly and systematic habits. The notebook is an index of how well this process is carried out.

Science deals with natural laws which are in themselves inevitable in an orderly arrangement of the universe. If the teacher is slipshod in his methods as to apparatus, punctuality, notebook work, etc., his attitude will be reflected in each pupil. How often one can trace the mispronunciation of a word throughout life—and escape from this pronunciation with only the greatest difficulty—to the careless teacher, who helps form our habits during the really important and impressionable years of our youth!

The science notebook is a field in which one can emphasize orderliness at the very outset. The science teacher cannot, however, fill the role of the teacher of spelling, penmanship, and English, and that of a science teacher also, and do all the work well. If all these features are included, some phase or other of the work must be neglected. It were well, therefore, if the science departments in high schools generally, could cooperate with the English departments to have the literary elements of the science notebook looked over, and thus accomplish the twofold purpose of scientific accuracy and literary excellency.

In initiating a science class into the use of notebooks it is well to remember that the pupils are quite ignorant, as a rule, of habits of orderliness, of ability to interpret, of literary perfection, and many other desirable qualities which we would like to develop in them. (This statement is equally true of adults.) The following suggestions may have some value in making the teacher's work easier, the pupil's work more definite, and general results more productive of just those qualities without which high school science in general and notebooks in particular become valueless.

Laboratory manuals, as a rule, are very excellent in giving directions; but for the beginner they presuppose, too much, the

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initiative which he lacks, for a careful record of results. The looseleaf direction sheet is, in the writer's judgment, preferable to the manual for this reason; if the loose sheet is used, care should be taken that directions be very definite.

Questions may advisedly be asked which are very carefully chosen, very definite in their thought, and frequently can be answered in monosyllables or in a very brief statement. Such definite questions would bring a well-defined thought to the mind of the pupil and a very definite answer, and would eliminate repetition of statement and obscurity of the written record when detached from the printed directions.

In discussing a difficult scientific problem with definite questions and monosyllabic answers as a basis, the manifold burden of spelling, literary composition, penmanship, and scientific accuracy would not be imposed upon the youthful investigator, nor would failure to comply with all the niceties of English composition remain a constant source of annoyance to the teacher who is obliged to review the papers. To find words habitually misspelled through carelessness on the part of the pupil is certainly not conducive to good nature on the part of the examiner; nor does poor penmanship produce psychologically beneficial results on the one upon whom the onus of looking over papers is placed. We may expect to have, therefore, by adopting the methods suggested for recording laboratory work, a very excellent way of lightening the work of both teacher and pupil. With the use of printed directions, correctly spelled words are constantly brought to the attention of the pupil; and if he sees them spelled correctly in the discussions which he is reading, he is not confronted with the demoralizing effect of a poorly constructed statement or sentence and a wretchedly written laboratory notebook. For this reason it seems advisable to have loose-leaf sheets with directions upon them which also have spaces for answers—in order to avoid repetition. The teacher examining such laboratory sheets, passed in periodically, will have his eye focused on the particular part of the sheet for the particular answer which he wishes to get. This arrangement will, therefore, save him a large amount of time to get the very specific results desired. The work of the examiner will be reduced a great deal for each paper, and one hundred papers may be looked over in a very much shorter period of time than when results are written in one hundred different ways, on one hundred different parts of the sheet.

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Moreover, the pupil and the examiner will have the assurance that every answer has been carefully examined and that the results are therefore more scientifically reliable for future reference. It may safely be said that most teachers looking over laboratory notebooks cannot afford the time to read every single word written therein, and this neglect becomes a serious source of error, often vitiating laboratory notebooks as reliable reference books later on. In this connection we should not overlook the value of a definite place on the sheet for the pupil's name, the date, and such further data as the teacher desires for his own use and records. The printed laboratory sheet will, of course, establish a geographical location for all necessary data.

Now, a word about sketches in the science notebook. This is an extremely important phase of notebook work. Sketches have little value if they do not serve to familiarize the pupil with the object that he is studying. He may have ever so clear an idea of the subject, but it will not be of a lasting character. A carefully constructed sketch will serve to perpetuate impressions, thus having psychological value. Sketches also, if accurate, will reveal to the youthful investigator many obscure or concealed details. Therefore sketches have scientific value. But to be of any value at all they must be mathematically accurate. The aim, therefore, should be to attain accuracy even at the expense of so-called artistic appearance. Exact proportions in biological material should be emphasized. This can be done with the help of the rule, the compass, and other instruments of measurement. Distinct outlines are, of course, a positive necessity. Material should be as nearly perfect as possible and should be held in such a position as will reveal most of the scientific facts desired.

Great care should be taken with labeling. Often, more particularly in biological work, all necessary labels may be given on the laboratory sheet and the pupil asked in class room discussions to label his sketch, selecting from the list of labels given him, the proper ones, and indicating them on the sketch. This has the advantage of permitting the pupil to retain initiative, and giving him correctly spelled words to copy. He will be obliged to use his intelligence to select the right label and his powers of concentration to copy correctly. Also he will not fall into the error of omitting important parts; for, obviously, those parts must occur in a sketch before they can be labeled. Such sketches can then be taken up in class en masse by the teacher,

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ıd each pupil can correct his own sketch for accurate labels. his will save time for all.

This procedure, besides being a time saver, is a further means impressing the relation of parts and the names given them. ɔor sketches, like misspelled words, ungrammatical statements, ıd illegible penmanship, are demoralizing and should not be ɜrmitted. Labels, for the sake of tidiness, may be put into a ılumn and to the right of the sketch, being connected with their ʻoper parts by dotted lines.

Copied sketches should not be entirely discouraged. Frelently such sketches are far more definite than an original etch may be, and will economically supplement the original etch. Like the plan of a house or the map of a geographical gion, the copied sketch, when used advisedly, will fill a very portant place in emphasizing desired details.

If anyone has the argument that this method of treating noteoks in high school science work is destructive of originality on e pupil's part, and is thus liable to the accusation of fostering ack of initiative and hence efficiency on the part of the student, him ask himself the questions implied by the discussion given us far. Is efficiency promoted by devoting unlimited time and ention to the consideration of secondary details, by allowing e pupil to neglect definiteness, orderliness, literary accuracy, d neatness? Can the average teacher afford the time to look er with the greatest care every notebook handed in, and thus tify its validity for future reference? If so, is the teacher's ıe, devoted to mechanical detail at the expense of his own inlectual and pedagogical efficiency, well spent?

In a matter as vital as the science notebook let us adopt methɜ which will get desired results in a manner most economic for concerned.

TIONAL WEALTH AND DEBT OF ALL BELLIGERENTS.

	Estimated National Wealth.	Present National Debt.	Per Cent.
ıat Britain	$ 90,000,000,000	$36,675,000,000	40.7
nce	65,000,000,000	23,000,000,000	35.4
ɜsia	40,000,000,000	25,400,000,000	63.5
y	25,000,000,000	7,000,000,000	28.0
an	28,000,000,000	1,300,000,000	4.6
many	80,000,000,000	31,000,000,000	38.7
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By Ralph C. Hartsough,
Physics Instructor, Wichita High School, Kansas.

One of the outstanding faults of our present educational system is its artificiality. The major part of its content is unreal in its adaptableness, inside and more particularly without the schoolroom.

And one of the glaring faults of our present day pedagogy is its superficiality. We have many old time-worn premises which are false and always have been. It is just as imperative to reconstruct our pedagogy as it is our system of education. They should both be brought down to the realities of actual life as lived in the world outside the classroom.

Not only should conditions in our institutions of learning and actions be placed on a more real and practical plane but the student should be handled with the same regard and the same severity that he will find awaiting him after school days are over. We shall then not find him as a hothouse plant, withering before the new standards that are set for him, but, having weathered exactly similar blasts during his school life, he will stand strong and sure. Then instead of 80 per cent of our high school and college graduates experiencing the usual setback at their first initiation into the school of hard knocks, they will at once function and not fail.

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The atmosphere of the classroom is very much different from that of business and social life. In school we still hold to many ancient ideas which not only work to the student's disadvantage during his school life but greatly handicap him after school days. The first of these ancient and old-fogy ideas is the putting of principle ahead of results. All through the grades, high school, and university, that false doctrine was drilled into me, and is still very much in evidence in most schools and colleges. Allow an illustration: If I knew to a nicety the most advanced theories and principles concerning banking and yet could not apply them and get results, the business world could not and would not use me. Accurate results come from knowing how, but knowing how is many many times so unproductive of right results. Correct results are the all important thing, and when we change our pedagogy and insist upon accurate thinking and accurate mathematics then our students will cease to be the inaccurate mental workers that they are. When a person is accurate and can get results, his confidence is a joy to look upon, and do not worry, he will weather successfully the modern world's demands upon him. Here is an illustration taken at random from many I might give: A class learns the principle that the volume of a gas at constant temperature is inversely proportional to the pressure. Yet when a problem is given using this principle we find these three classes of students: (1) Those who write the equation P_1V_1 equals P_2V_2 but are unable to go further. (2) Those who set up the equation and substitute correctly, yet on account of inaccurate mathematics do not attain the correct result. (3) Those who solve it correctly. After many trials on different principles, the per cent of students in these three classes is as follows: (1) 10 per cent, (2) 80 per cent, (3) 10 per cent. It is evident that these 80 per cent class two students are getting by with this class of work in our grade schools, high schools and colleges simply because it is customary to give half or more on correct principle. Emphasizing principle and not holding for correct results promotes carelessness and inaccuracy in our students. We misplace the emphasis and the all-important result is lost to sight.

Next, let us look into our scheme for passing or failing students. In general, we set too low a standard as the dividing line for passing and failing. Let us return to the banking illustration used above. Could a banker retain the services of an employe who would grade 75 per cent or even 85 per cent? No, he must

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have the 90 to 100 per cent man. This is not only true in banking, but other business is the same. In the actual life of business and social affairs we demand accuracy and efficiency. There is no doubt that our students do not extend themselves to go beyond our expectations of them. We allow 70 per cent of subject mastered to pass and the majority hover around that point. In three schools with which I have intimate acquaintance the passing marks are 60, 70, and 75 per cent. The system of grading used in all three was an endeavor to say the student had grasped that per cent of the course. In these three schools the per cent of normal, superior and inferior students did not materially differ, but the standard of scholarship in the 75 per cent school was far ahead of the 60 per cent institution. If we would grade our students into inferior, normal, and superior, then divide the normal into inferior, normal and superior normal, it seems then we might set a higher standard for passing. The superior and superior normal should be the passing students while the inferior normal and inferior ones should repeat. Or on the basis of the per cent of subject mastered, students below 75 per cent should repeat.

We must rectify deeply and much in our pedagogy, as well as in our educational system, if we are to take front rank among the nations, for the oriental mind is fast overtaking us and will soon be rivaling our boasted superior intellects. We must produce graduates who will make good from the start so that the indictment of one of our big business managers will no longer be true. He said, "The majority of the graduates of our educational institutions lack confidence and are too inaccurate for any use." The utilitarian idea has steadily been gaining in our educational system and with it must come the sloughing off the curriculum of many subjects of doubtful usefulness.

We must introduce new subjects designed to help the student find himself. The crying need of our schools right now is an expert to discover the student's natural bent and assist the student in choosing aright his life work. This life, with its competition and specialization, has no place for the useless. Let everything in our system of education contribute to student's future enjoyment and worth as a citizen, and then our schools will serve the purpose which modern life demands of them.

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PEDAGOGICAL EXPERIMENTS FROM THE BIOLOGICAL LABORATORY OF THE DeWITT CLINTON HIGH SCHOOL.

By Geo. W. Hunter, Ph. D.
DeWitt Clinton High School, New York City

The DeWitt Clinton High School is one of the largest schools in the United States, having at the present time about five thousand students within its doors; it is also one of the greatest college preparatory schools in the country. The Department of Biology and Hygiene has the unique privilege of administering to all of the students in the school. Every boy who receives a diploma must take one year of elementary biology, given during the first year of his course. In addition to this, he has instruction in hygiene one period each week throughout his school career. The department consists of twenty teachers, and the actual number of students registered for work last term was 4,185. Of this number, about two thousand take courses in elementary and advanced biology.

It is evident that if the teachers of biology are specialists, as they are, and are interested in the problems of teaching, as this series of articles will prove them to be, that this school gives a rather interesting opportunity for experimental work, not only in the content of the course, but also in the methods of teaching. Those of us who are familiar with the suggested lists of experiments given in a bibliography published in School Science and Mathematics, January, 1911, by W. L. Eikenberry, may remember some of the suggested experiments outlined for solution. Several of these experiments, concerning the method of study best adapted to classroom and to laboratory work with young pupils, have been attacked by the writer. A somewhat extensive article on this topic will shortly appear in one of the pedagogical magazines published in this country. This same article also takes up certain other phases of the problems of biology teaching, basing the solution of the problem upon the interests of the children in biological science material rather than methods of presentation of the subject.[1]

It is not my intention in this brief article to call attention to this piece of work, but instead to introduce a series of experiments which are at the present time in process of performance in this school. The first of the series was brought about in an

[1] "A Critical and Experimental Investigation of the Present Day Secondary School Methods of the Teaching of Biology in the United States," G. W. Hunter, Ph. D.

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attempt at standardization of the teachers' work within the department.

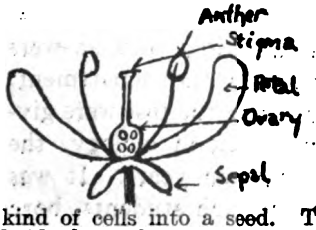
For several years it has been our custom to mark our final examinations in committee, each member of the committee being responsible for the marking of a question or group of questions on the papers. Owing to stress of work at examination time, and the fact that such methods of examination were not economical of the teachers' time, the members of the department voted to go back to the individual marking of examination questions. This has been done for the past two years, but in order to try out the reliability of the individual teacher in examination rating, the following experiment was proposed and started by Frank M. Wheat, a former member of the department. Owing to Mr. Wheat's promotion to the care of a school of his own, the experiment has been finished and written up by me:

We are all familiar with recent work on the unreliability of examinations as a test. In the work of Starch and Elliot[2] we find that individuals have graded mathematics papers with very great differences in individual marking, and in his recent book[3] Starch has given numerous examples of the individual unreliability of teachers' examination grades. In order to test the reliability of grading in our own department, the following mimeographed sheet was sent to each teacher in the department:

To Teachers of Biology:

Kindly find herewith a copy of ..... X's..... paper, giving questions and answers. Please grade the same and return to the Chairman tomorrow morning. Each question has a value of twenty (20); the parts of the question, as indicated. Do not sign your answer paper.

Q. 1. (a) Draw a sketch or diagram (5) and label five parts of the essential organs of the flower (5). (b) Give the use of any three parts labeled (6). (c) Tell very briefly how the seed and fruit are formed (4).



Ans. (a) (b) Petal attracts insect because of color. Anther produces pollen. Stigma is sticky, receives and holds pollen. (c) Two processes, pollination and fertilization, take place. The bee leaves the pollen on the stigma, causing fertilization; pollen grows down the pollen tube, and enters the ovule; the sperm cell fertilizes the egg cell. Then the ovule develops by increasing the number and kind of cells into a seed. The ovary changes, grows into a fruit and holds the seeds.

Q. 2. (a) Draw a seed (2); label parts of embryo (3). (b) Prove by experiment that the seed contains a nutrient (5); (c) What carbohydrate

[2]Starch, D., and Elliot, E. C., "Reliability of Grading Work in Mathematics," *School Review*, Chicago, April, 1913, Vol. 21, pp. 254, 259.
[3]*Educational Measurements*, D. Starch, McMillan, 1916.

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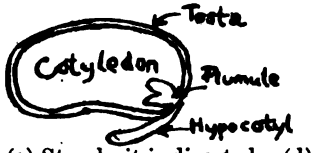
is found in the bean seed (1)? Explain what is done with this when the seed grows (4). (d) Why does digestion occur (5)?

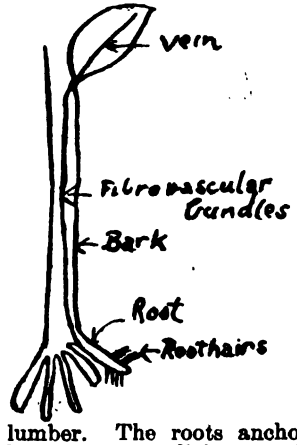


Ans. (a) (b) The seed contains a nutrient, starch. We know this because we can prove it by testing part of the seed, the cotyledon, in a test tube, adding water, shaking, boiling, cooling, adding iodine and getting a blue color which is the test that proves that starch is present. (c) Starch; it is digested. (d) Because an enzyme is present in the cotyledon of the bean.

Q. 3. Growing seedlings need air in order to grow. Show, in the form of an experiment, what part of the air they use (20).

Ans. I took some seeds and put them into a jar. I then sealed the jar tight. After several days, I looked at the seeds and noticed they had not grown. I then tested the air of the jar and found carbon dioxide present. I therefore conclude that plants use oxygen.

Q. 4. Make a diagram of a bean or a pea plant to show the path by which water from the soil reaches the leaves. Label all the parts of the diagram and explain the use of each part labeled (20).



Ans. (1) Root hairs, the organs that take up water.

(2) Root, lower part of plant.

(3) Bark, outer part of plant.

(4) Fibrovascular bundles, tubes through which water goes up stem.

(5) Veins, the places where water gets into the leaves.

Q. 5. (a) Give the use of seed (2), stem (2) and roots (2) of a plant to a plant; and to a man. Give examples. (Total 12 points.) (b) What does a plant take from its environment? (8)

Ans. (a) Seed is used to produce new plants, as a food for man; ex.: beans. Stem is passageway for food and holds up leaves, food for man; examples: leeks, lumber. The roots anchor, storage, take in water, food; examples: beet, carrot, medicine, root beer. (b) Air, through leaves; soil and water, through roots; light and temperature.

The above questions and answers were bona fide questions and answers taken at random from different papers and the whole made into a composite paper, so that the members of the department were confronted with actual questions and answers which were known to only one member of the department, Mr. Wheat. The several questions comprising the test were given to students during their first term's work in biology, the age of each student averaging about fourteen years. It was obvious that the biological information of such students, born and nurtured in a great city, would not be very great. The results of the ratings given by fourteen different teachers are extremely interesting, as they show a very great variation in grading. So far as I am aware, no previous experiment in grading

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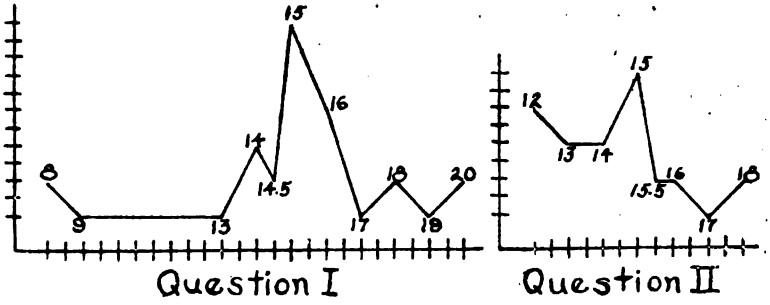
had been given in which the teacher had a definite weight for each question and part of a question graded.

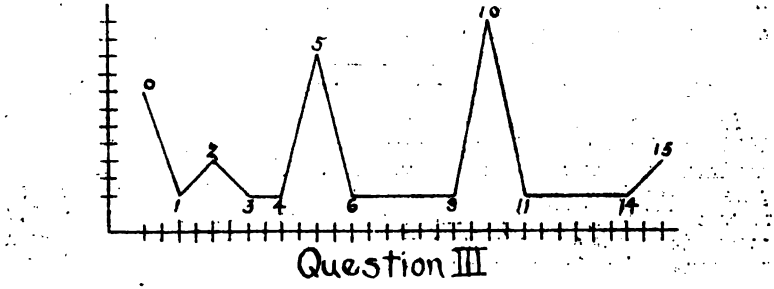
A COMPARISON OF TEACHERS' MARKS.

Teacher	Question I.	II.	III.	IV.	V.	Total
A	15	12	5	15	17	64
B	18	16	0	16	16	66
C	16	15	0	15	16	62
D	15	15	2	13	15	60
E	8	13	10	15	14	60
F	16	12	0	15	17	60
G	14	15	5	15	16	65
H	16	12	5	10	17	60
I	14	15.5	15	15	11	70.5
J	15	14	10	13	18	70
K	14.5	18	10	16	16	74.5
L	15	15	10	14	16	70
M	15	13	5	11	16	60
N	20	14	10	12	18	74

A glance at the preceding table shows an astonishing range in



grades, even with a carefully worked out schedule of ratings already given the teacher; for example, Question 1: the range is from 8 to 20 points, the median of the curve being 15. The second question which, by the way, is a bad series, shows a flat curve ranging from 12 to 18 points. In the third question, owing to lack of rigidity on the part of some teachers or carelessness



as to the meaning of experimental form, the ratings range from zero to 15 points; in the fourth question, a slightly more uniform rating obtains, a smooth curve showing, the rating being from

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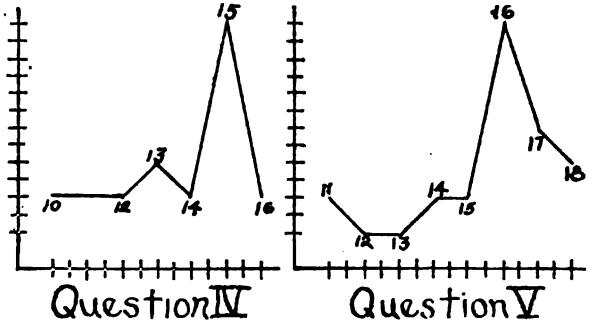
10 to 16 points; in the fifth question, a fairly uniform curve is seen, the median at 16 points, in range from 11 to 18 points. The conclusions from the above series of ratings, if any, would appear to be as follows:

First, that much more care than is usually given should be placed in the making out of examination questions. If fourteen



adults, well trained in the technique of making and answering examination questions, and especially trained in the knowledge of the content of such questions, can so far misinterpret questions and answers as to give the variation quoted above, then to what extent can we look to our pupils for clear interpretations of carelessly worded questions?

Second, if the individual variation in marking is as great as has been shown in this and many other experiments, then very little reliability could be placed on examinations which are marked completely by individual teachers. It would seem that committee marking would be much more reliable than individually marked papers, if the pupil is to be judged by the mark.

Third, this experiment, or others of similar nature, should be tried in a number of different schools, so that some definite criterion for marking questions might be established.

MID-YEAR STATISTICS ON PRODUCTION OF POTASH.

The statistics of the production of potash for the first six months of 1918 received by the United States Geological Survey, Department of the Interior, to date show a total output of 20,000 to 25,000 short tons of pure potash (K_2O), indicating that the output for the entire year may reach 50,000 to 60,000 tons. As only 32,573 tons were produced in 1917 the production is evidently increasing rapidly. The domestic production now equals 20 to 25 per cent of the normal domestic consumption before the war, which is estimated to have been about 240,000 tons. The statistics for the first half of the year are not complete, for returns have not yet been received from a few large producers, and it is possible that the production in 1918 may exceed 60,000 tons, for reports made to the Survey indicate that a number of new enterprises may be put into operation during the second half of the year.

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UTILIZING WASTE FAT FOR SOAP—A PROJECT FOR THE CHEMISTRY CLASS.

Experiments in soap making are included in most laboratory manuals. Performed in test tubes or small evaporating dishes, they are generally unsatisfactory. Saponification proceeds with difficulty or not at all, and only in rare instances does the student succeed in getting a product which he can recognize as soap, or with which he would be willing to wash even his hands. If the experiment is attempted on a larger scale, as directed in a few manuals, the expense for materials becomes excessive, and there is little spur to the student's interest to attempt the production of a larger amount of soap.

The present high cost of soap, the need for strict economy, and the utilization of all materials formerly wasted, furnishes an opportunity to the chemistry teacher to put the preparation of soap on a new and better basis, making it a real project in which the student may feel the value to himself, to his family, and to his country as well. Here is an opportunity to make the chemistry course function in daily life by converting fat, which formerly went into the garbage pail, into soap which in color, cleaning power, and lasting qualities, compares favorably with that purchased from the grocery store. The following plan was followed by the chemistry class last spring, and, with some modification, will be used at a much earlier date with this year's class.

The relation of chemistry to the war is a general topic whose ramifications extend in many directions, and which may be depended upon to stimulate and arouse the pupil's interest whenever this connection can be made. The study of explosives came up logically after the class had made and studied nitric acid in the laboratory. The manufacture of guncotton, nitroglycerine and T. N. T. (tri-nitro toluene) were talked over in this connection, and the sources of supply of the raw materials for these products were investigated. The growing need for glycerine and its mounting cost brought out the importance of fat conservation and the more efficient utilization of fat in every home in the land. Pupils were asked to make an investigation at home, to see if any fat was wasted, and to urge the wider use of meat drippings as a substitute for butter and lard, and to see to it that any unused fat was carefully saved for use later in soap making.

The pupils were also asked to bring in recipes for soap making

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which mothers or grandmothers had preserved from the earlier days when most families made their own soap. A number of these were collected and compared, as well as directions in various manuals and books. The following laboratory direction sheet was prepared on the basis of such a recipe, brought from the home of one of the pupils, after it had been tested and found to give satisfactory results.

SOAP.

5 lb. Fat
1-2 lb. Borax
1 can Babbitt's Potash

Dissolve the potash and borax in three quarts of hot water, in an iron or enameled dish, and allow to cool. Melt the fat, and strain through two layers of cheesecloth, and allow to cool until pasty but not hard. Add the fat to the potash solution very slowly, a little at a time, and with stirring. After all the fat is in, stir slowly for ten or fifteen minutes, until the soap sets or becomes pasty. If the soap does not set after fifteen minutes of stirring, give it an occasional stir until it does become pasty. Pour out into a pan lined with waxed or oiled paper. When hard, cut into bars. If coloring matter is added, do so after all the fat is in and the stirring has proceeded for ten minutes. This soap sometimes floats on water. After the soap has hardened, it may be remelted by gentle heat and poured into moulds of various sizes and shapes. The soap should dry out for some weeks before it is used.

By the time the directions were settled, most pupils had accumulated at home from five to ten pounds of fat and set about the preparation of their first batch of soap. As might be expected, saponification took place at varying rates, and discouragement nearly overcame a few. One girl essayed a double batch and reported a complete failure. She was encouraged to keep on with the work, and the next day reported that on her return from school she had found her soap thoroughly set, of good appearance, and of such density as to float in water.

One member of the class, interested in Red Cross organization, gave a talk on soap making as a war economy, and passed on the directions for soap making to the other members. The same pupil followed up soap making after the close of school, and experimented with scents and dyes with such success that a sample of her product was placed on exhibit and will help this year's chemistry class in repeating the work and carrying it on still further. The school lunch room has been called upon to conserve all fat to the uttermost, and the accumulation is to be turned over to the class for conversion into soap. This work will be done by groups of pupils at the close of school or in free periods. The domestic science class is also interested and will further the work among its members who are not in the chemistry class.

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THE METHOD OF THE SCIENTISTS.

By Morris Meister,
Teachers College, Columbia University, New York City.

Back in my undergraduate days we had a professor of physics whose delight it was to emphasize the logical development of his subject. As he told us again and again, the most important thing for us to get was first, physical concepts and second, scientific method—the method of the scientists. And so he spent the whole term in a course on electricity and magnetism, deriving the fundamental notions of unit of electricity, unit of current, unit of potential, and unit of resistance. He was minuteness itself in the detail with which he discussed what was definition, what was assumption, and what was experiment. In the laboratory he insisted on the most orderly arrangement of apparatus —on the extremes of accuracy—and any minute he was apt to interrupt, destroy our previous readings and start us over again because we had omitted some small step in his logical system. In a subject which has become as much a part of our lives as the very clothes we wear, this was his final examination, just one question, "Derive the fundamental quantitative relationships of Electricity and Magnetism."

I am not going to condemn his method nor his subject matter. Neither will I venture to estimate of what value the course has been to me; for I must confess I have now no means of judging. Just this do I want to make a point of, that three years later I had the good fortune to work in the same laboratory with this professor—I in a graduate course, he on a piece of his own research. I became rather interested in his problem and he was very willing to discuss it with me. He was working on a photometer that would eliminate as much as possible the eye in judging different shades and tints, and he had an idea. For days at a time he tried out the wildest of schemes. His table was a mess of apparatus, and his desk a mess of books and papers. He seldom took readings, and accuracy was the least of his concerns, though his instrument was a maze of scales and verniers. The most striking part about his work was his enthusiasm and the ingenious little tricks that he had of improvising apparatus that would short-circuit laborious method and make unnecessary great accuracy. His work, I hear, has been recognized as meritorious and quite a contribution to science.

I submit in rather detailed form this incident to raise and define the question of method as I want to discuss it in this paper.

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There was certainly an inconsistency in the method of scientific research which my professor employed himself and the scientific method which he imposed upon us as students. I am safe, I am sure, in assuming that such an inconsistency is rather common with teachers of science, and also that any teacher or professor when attacked on pedagogical grounds will point at once with calmness and confidence to the "scientists" and show that he is getting his pupils to study by the "method of the scientists." Thus the problem arises: What is the method of the scientists?—and what is of paramount importance, this question is not merely one of academic interest. It is not that we want to catalogue the different methods of scientists or analyze them for common elements and so evolve a "method" that all scientists follow or should follow. But it is in reference to the teacher in the classroom that the question has its interest. I see involved in it the underlying principle of building the course of study in science, if not a solution to the problem of the curriculum as a whole.

If we adopt the idea that the experience of the human race is embodied in the sciences and that the method of life found most effective thus far is the method of science, then the curriculum as well as educational procedure in general centres itself around science and scientists. The latter terms are here used in their most comprehensive sense.

Educators and philosophers have always recognized this role of science; as witnessed by the work and writings of men like Bacon, Descartes, Locke, Kant, Mill, Spencer, Mach, and Poincare. Each of these men has analyzed the method of the scientist in his own way. Each of these men has built his metaphysics, his "grammar of science," and each in his day has affected or is affecting the problem of education in accordance with his analysis. And around each of these analyses there usually grow up small groups of professors who idolize that particular type of research or who throw all work in science into their particular mold. One is struck in pursuing the literature in the method of science to find the definiteness of the steps in scientific thinking and discovery. It is this definiteness against which science teaching is now struggling. Inductive teaching, whether it be Bacon's or Mill's or Locke's, is not satisfying the demands of the world—neither is the deduction of Descartes nor the induction-deduction of Mach and Poincare. The results are poor, not only in the classroom but in the research laboratory as well.

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When I express this dissatisfaction with the metaphysical analyses of the method of science it is not that I dare to discredit them nor that I do not see the value of these works as works. These ideas become insidious only when we attempt to graft them on immature minds. My professor of science, after a lifetime of research and study, comes to a real appreciation of science. He can see with Newton the whole universe in terms of F = ma. This symbol takes on a wealth of meaning and it gives him distinct pleasure to use such a short hand for his ideas. He cannot, however, resist the desire to teach his terminology and so he imposes in the very first lesson this symbol on his pupil. What is more, he grows impatient if the latter holds the formula in contempt, doesn't remember, cannot use it and does not appreciate it. He assumes a holy attitude—looks down commiseratingly on the poor ignorant soul who is not made of the clay of science, who has no reasoning faculty and he grows intolerant at the desecration of the holy things of science by so lowly a mind. The great distinction that we lose sight of is that a metaphysical analysis of the method of science, such as Poincare's for example, treats of the *work* of the scientists, while any aid which the teacher can get will come from watching the scientists *at work*.

The science teacher may be pardoned who, after perusing Prof. Pearson's "Grammar of Science," is still left perplexed about the "reality of things," "reason behind nature," "cause and effect," "space and time," and who cannot, as the director of twenty-five young lives in the realm of science, see scientific method along such lines.

And so to return to the problem, we shall in a sense attempt to analyze the method of the scientist and not of science. Who are the scientists? For the teacher they can be but the men who have given us our present stage of knowledge and civilization. Because he takes no stand on the various schools of metaphysicians he can disregard the distinction between pure scientist, practical scientist and inventor. Here is his list, which no one can deny at least includes the scientist, whomever else it may include: Archimedes, Galileo, Newton, Darwin, Kelvin, Pasteur, Dayy, Faraday, Maxwell, Helmholz, Kirchoff, Mendeleef, Edison, Meyer, Roentgen, Priestly, Bunsen, Cavendish, Berzelius, Charles, Gay-Lussac, Lavoissier, Ramsay, Scheele, Van Helmont, Morse, Curie, Bertholet, Rumford, Boyle, Avogadro, Black, Dewar, Graham, Ostwald, Rutherford, Thomp-

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son, Bessemer, Franklin. I might add that this list is in no way exhaustive; it merely represents the lives that I have in some measure been able to investigate.

It does not take long in such an investigation to be struck with one fact. Whether it be the abstract thinker Newton or the gross materialist Edison, each pursues his work with an enthusiasm so intense that there is nothing to which his work is subordinate. Wealth, happiness, friendship, life and limb, are all placed on the altar of science. Very few of these men had their work chosen for them by parents or friends; in fact, in nearly every case they had to oppose efforts to place them in certain definite positions in life. Something drew these men on which alone can account for their spirit of enthusiasm and this was not the "poetry of logic." Newton under the apple tree, Galileo at church watching the swinging lamps, Archimedes and King Hiero's crown, Pasteur and the silkworm disease in France, Davy and the coal mine explosions, Hooke and Huyghens and their need for a timepiece, Halley and the meteors, Faraday and Arago's rotating disc, Roentgen and his fortuitously developed photograph, Cavendish and his burning hydrogen, Galvani and his frog, Edison and the present submarine crisis—to me all this presents one picture—a scientist perplexed, a scientist seeking a solution, a scientist with a problem on his hands. It is that which explains his enthusiasm. A vital, pressing need forced itself upon his attention, by accident or as an outgrowth of some previous problem, and because of its vital nature gripped the man, not letting him rest.

The more we go into the details of things which occupied the minds of these great men the more we are led to the conclusion that life to them was a series of doubts; so much so that I am ready to say that the sine qua non of scientific method is perplexity.

Professor Mann, in his chapters on the Pedigree and Method of Physics, goes to the extent of saying that these pressing needs have kept pace with the development of industry and that science and its method are the outgrowths of industry. In tracing this growth he notes first, that "the process by which it was accomplished was this: some human need, desire, longing or aspiration made itself felt, whereby a problem was defined—a problem that would not lie down and keep quiet until the need that called it into existence was satisfied." Second, that "the solution of one problem reacted to stimulate new needs and desires;

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id these in turn defined new, more refined, and more difficult oblems." Third, that "the success of this upward move- ent of industry and commerce was due to the fact that they ere able to 'deliver the goods' that were needed to satisfy the man desires that called them into being." And fourth, that he discoveries achieved by this method of solving problems ere so concrete, so impelling, so undeniable that even the fallible church had to succumb. . . . When large bodies men had thus become accustomed to thinking in this way, e time was ripe for the extension of the method to the solu- on of more general and abstract problems. Then it was that odern science proper began."

In a like manner Dewey treats this same matter of perplexity the first ingredient of the scientists' method from a different gle. "Wonder," he says, "is not only the originator, but it the continuer of science. Wonder is the emotional outgoing the mind toward the universe. It is the sole spring which n take a man beyond his subjective states and put him into at active relation to the world which is the sole condition of tting at its meaning. But it is no less true that wonder is the use of all growth, of all increase of knowledge."

Now, whether we adopt Mann's extremely materialistic no- ons of the kind of needs which urge scientists on, or Dewey's ore altruistic notion, or as Mann actually suggests consider dustry the father and Wonder the mother of modern science, to the teacher really immaterial. The emotions are the prime overs of the child—we cannot say, whenever we are ready and our own most suitable way, "Now, children, you must engage scientific thought." Newton couldn't do it, Galileo couldn't it, Faraday, Darwin, Kelvin, Maxwell, Archimedes, Pasteur, iestly, Rumford, Boyle and all the rest couldn't and didn't it.

I have outlined and discussed what is believed to be the first tep" in a scientist's work; but it would be useless I feel (for actical pedagogical purposes) to carry the process further as a ries of steps; not because these steps are not followed, but cause they are followed automatically and unconsciously. here is a period or stage in the scientist's work when his diffi- lty or perplexity is not clearly defined, and then he does nsciously apply criticism and experimentation. Thus Davy's ental machinery did not begin to function properly along entific lines until he had examined the kinds of gases that used explosions in coal mines and had seen the futility of ven-

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tilation. It was a clear definition of the difficulty that set him to working on a lamp which would give light without bringing the explosive mixture to its kindling point. And so it may be of value to note this second "step" in teaching; but to carry it any further as a program would be creating another "grammar of science." And yet what is it that the scientist does unconsciously or automatically? In the words of Tyndal, "from a starting point furnished by his own research or those of others, the investigator succeeds by combining intuition and verification. He ponders the knowledge he possesses and tries to push it further; he guesses and checks his guesses; he conjectures and confirms or explodes his conjectures. These guesses and conjectures are by no means leaps in the dark; for knowledge once gained casts a faint light beyond its own immediate boundaries." This stage of the scientist's work can almost be termed the art of science. The genius of the man is at full play—his intuition, his knowledge, his very being is concentrated on the difficulty before him; and inspiration plays as great a part with him as it does with the poet.

Count Rumford, for example, in carrying on tests on the rate of cooling of certain bodies, prepared two bright metallic vessels which he filled with hot water and placed in a large quiet room. As he progressed, it suggested itself to him to cover one with Irish linen and note the result. He next tried glass vessels, both with thick and with thin walls. He coated one vessel with a layer of glue and then added several layers more. He painted some black and some white, etc. His different tests were not entirely at random, and yet he couldn't say what it was that led him to the right path. The laws of radiation were his inspiration. Again, let us watch Faraday at work. He needs an electric machine, and so he inverts a four-legged stool to serve as a stand. He takes a glass bottle for his cylinder, fastens a cork into the mouth and a bung in the other end. Into the cork he inserts a handle for rotating the bottle, and in the centre of the bung a wooden pivot on which to turn; while with some stout wire he makes crutches on two of the legs of the stool for the axle to work on. The silk rubber he holds in his hand and a Japanned tea-canister resting on a glass tumbler forms the conductor, while the collector was the head of a toasting fork. Or again, let us watch Jacques Loeb at work. There is something uncanny about the way he adjusts the conditions of his experiments to bring results. Why choose a solution of salt in which

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to throw his pulsating animal forms? Salt alone gave him his result. Now he cuts a cube from a cell and it grows tentacles. Now he cuts a new mouth in an organism and observes the struggle between new and old, so that part of the body is led to involuntary suicide. He seems to "sense" the truth. This aspect of the scientific investigator had so impressed Priestly that he himself said: "Many of my most startling discoveries were the result of chance operations—not of themes worked out and applied."

The same trait can be found (and had I the space I could multiply the instances indefinitely) in nearly every scientist. The glimpse of truth comes not as the hard conclusion of logical steps but evolves almost accidentally from almost hundreds of tests and trials ingeniously devised and artistically controlled. The longing, the desire, which furnishes the motive to keep the scientist at work, somehow induces hypotheses, trial solutions and tricks to force nature to give up its secret. What is more, this is true not only with men of science but with men in the lowliest walks of life. It is the natural way in which our brains act; and is it therefore reasonable to imagine that children will become scientific thinkers if we simply put them through the motions called for by the steps in the formula? We must induce in them motives in some way similar to those which impel real scientists doing real investigation.

I tried recently to get a class in science to re-live the motives and experiences of Davy in the work which led to the invention of his lamp. I pictured the conditions in his day—how England was repeatedly shocked by the great explosions in the coal mines; the destruction of life and property, the misery and destitution. I showed how the development in the iron trade and of the steam engine was making more and more demand upon the coal supply; and how the intensive working of the mines extended and aggravated the evil. In the old days when the pits were shallow, fire damp, although not unheard-of, was little dreaded and explosions were rare; but as the pits became deeper and the ways more extended the fire damp accumulated. I pictured a miner crawling along a dark, narrow crevice, groping his way with a candle, and then, before he knew it, the terrible roar of the explosion caused by the candle in his hand. Things went from bad to worse, until the companies even forced the newspapers not to print news of the explosions for fear of arousing public opinion against them. How could the mines be cleared of fire

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damp? (the class certainly saw the problem). Various means were tried by different men, such as ventilating schemes, spark wheels, flushing with chlorine, airtight lamps, etc.; and I led the class to see why each failed. The demon of the mine grew more and more formidable and mechanical science seemed to have spent itself when Davy was called upon. He visited the mines, brought back samples of fire damp and commenced work. He soon found that fire damp needed a high temperature to explode it and that the flame formed by the union of air and fire damp would not pass through tubes of certain diameter. Glass tubes were tried but were found to be not as good as metal tubes, and wire sieves were very good. He tried an electric lamp, but that failed, and so he finally decided upon a lamp that would use the very explosive mixture to give the needed light. He made eleven different lamps, which at last determined the proper one, and he tried it out first in an explosive mixture on the surface and then in a mine. "It is impossible for me to express my feelings," he says, "at the time when I first suspended the lamp in a mine and saw it red hot. I said to those around me, 'We have at last subdued the monster.' "

The above is only one of the many illustrations of how a project of a scientist can be made a project in the classroom. It shows as well the genius of the man at play in its total disregard of logical steps. In the words of Prof. Mann, "While a physicist is laboring over a real scientific research, he finds it difficult, if not impossible, to guide his thinking according to any logical formula. But when he has solved his problem, he describes the process by telling how he first sensed an inconsistency or a gap in a system of ideas which were concrete to him; how he then, by search for related ideas and facts, or by both, succeeded in defining the problem sharply; how he formed a plan of action or theory to serve as a tentative solution of the problem; and finally, how he deduced the consequences of his theory and tested them by experiment. This is excellent form for telling about his investigation after it is done. But it is clear enough that he never laid out his investigation in advance in any such sharply defined steps. During the process of the solution he was constantly associating, dissociating and ordering ideas, making inductions, deductions and verifications; and, in short, thinking as we all think by processes that are too complex to be analyzed."

Our analysis of the scientist at work has thus far brought out:

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(1) That he begins in a state of perplexity.

(2) That he works with an intense enthusiasm because this perplexity is the result of a real, pressing, vital difficulty.

(3) Once the difficulty is clearly defined, his enthusiasm carries him to a solution by a process which is automatic but which can be described as:

(a) A process of rapid suggestion, supposition, guess, hypothesis or theory—pending further evidence.

(b) "Reasoning out" the implications of each suggestion.

(c) Deliberately and cleverly arranging conditions in accord with the requirements of any of the suggestions to see what results occur and to weed out the false suggestions.

The superiority of such an analysis over one which sets up certain definite steps lies in its implications for the teacher. The whole of life can be thought of as a series of problems or hurdles, the series progressing from the simple needs of childhood to the intellectual needs of the educated adult. This line of growth cannot be short-circuited, for each step is prerequisite for each succeeding one. The teacher's task becomes simple and yet difficult; simple, because he must merely commence the process by so controlling the situation that a need or problem will arise for the child—the rest, within certain limits is automatic, and yet difficult, because these limits are the capacities of the child; and to properly gauge these and take them into account requires teaching ability of a high order.

On this basis we can now see clearly the distinction between pure scientist, practical scientist and inventor. Was the method of Newton, Kelvin or Maxwell any different from that of Priestly or Rumford or from that of Edison or Morse? Our analysis shows that there was no difference in method, and our conception of life as a progressive series of problems involving the above analysis in their solution accounts for the difference in results. Up to eighteen years of age Newton and Maxwell were Edisons; up to thirty they were Priestlys and Rumfords; and in their prime they were themselves. What I wish to say is that with the changing character of their "perplexities" we have the changing of results; and the labors of their later years were made possible by those of their youth. We usually think of Newton as the abstract thinker and philosopher whose problems were those of the universe. Newton as a boy spent his time making model windmills, water clocks, self-propelled carriages, kites, sun-dials and reflecting telescopes. He would delight in cal-

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culating the velocity of the wind by jumping against it and with it. He was a little Edison at work. These projects gradually developed till he found himself pondering the question of gravitation. That his method and attitude were always the same is illustrated by these words from his own pen: "I do not know what I may appear to the world, but to myself I seem to have been but a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." The same was true of Maxwell as a boy, of Kelvin and all the rest of the abstract school. The fact that they outgrew these early stages makes them the great scientists that they were. Men like Rumford outgrew the early inventive stage but could not or would not be "perplexed" by anything the solution of which would not be of great material value to the human race. Rumford, for example, spent a good part of his life in trying to devise a method of using up the unused material in the smoke which habitually hung over London; and spent a good part of his fortune on his dream of "forming, by subscription, in the metropolis of the British Empire, a public institute for diffusing knowledge and facilitating the general introduction of useful mechanical inventions and for teaching by courses of philosophical lectures and experiments the application of science to the common purposes of life."

In thus calling Newton a scientist of the first water, Rumford a scientist of the second, and Edison one of the third, I wish to make it clear that it is not their contributions to the world's welfare that I am attempting to estimate. It is merely distinguishing three types of men who, though employing similar methods of work, arrived at different results.

Now I said in the very beginning that it is in reference to the teacher in the classroom that this question of method gains its interest and importance. A scientist at work is but a human being at work—a human being who has accomplished something. What is more, adding up the accomplishments of these men we have what we are trying to put into our curriculum. Now shall we take the results of these men, predigest them, and feed them to our children, or shall we learn from the method that these results were obtained the way to hand it over to the child? The scientists have explored unknown regions and have charted the ways. The curriculum is the map which they have left us; but each child must in a measure live through the ex-

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periences of the pioneers and reconstruct for himself their map. Thus we have the justification of the project method of study and especially for the project method of studying the sciences. The lives of the scientists are lives full of projects, which projects should now become the projects of the schoolroom.

The great evils of the science teaching of today are due chiefly to the adherence of science teachers to a false analysis of the method of the scientists. The formal logical steps of Bacon or Mill or some of the other metaphysicians attack the problem from the wrong end, as far as the educator is concerned. It is Dewey's analysis of thought which I have attempted to apply to the work of the scientists that I believe will solve the problem of science teaching.

HARDSHIPS EXPERIENCED BY RASMUSSEN'S SECOND THULE EXPEDITION.

The expedition, composed of Knud Rasmussen, leader; Dr. Thorild Wulff, Swedish botanist and ethnologist; and Lauge Koch, geologist and cartographer, left its base in North Star Bay in April, 1917, and proceeded successfully as far as St. George's Bay (82° N.). Here game failed them, so that, with the exception of a few hares, and a seal or two, they killed no food at all. Unable to proceed beyond De Long's Fiord, about a degree farther north, they turned homeward at that place. One of the Eskimos, Hendrik Olsen, who distinguished himself in the service of Mylius Erichsen's East Greenland Expedition several years ago, was killed and eaten by wolves while out hunting game, just before the party mounted the ice cap to start back to North Star Bay.

The journey across the ice cap was accomplished in the face of almost incredible difficulties. The party ate the dogs one after another; just after the last dog had been eaten they reached Cape Agassiz, near Humboldt Glacier, on the west coast. They were all weak, exhausted, and starving. Knud Rasmussen and one Eskimo started immediately for Etah to obtain succor for the others, who were to follow along more slowly, living on the game that they hoped to kill, until help reached them.

Unfortunately they could find neither hare nor caribou, and in a few days Dr. Wulff became so weak that he could go no farther. After writing brief messages to his family and dictating to Koch a summary of his observations of the flora of the lands immediately south of the Humboldt Glacier, he bade his companions farewell and resigned himself to his fate. Koch, whose strength was fast waning and who was too weak to encourage Wulff to proceed or to help him in any way, continued slowly with the two Eskimos on the weary way toward Etah.

Dr. Wulff had continued his scientific labors to the last. According to the letters, he accomplished a splendid piece of work, both in botany and zoology. He had continued his observations until he could go no farther and died, as a brave man would, in the field of his endeavors.

Koch also accomplished satisfactory work. He mapped the entire coast along which he traveled, including several new fiords that he discovered, and collected Silurian and Cambrian fossils far north. According to a letter from Upernivik, dated January 23, 1918, he had not then fully recovered from the effects of his exhaustion and starvation.—[*Geographical Review.*

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Why One Should Attend the November 1918, Meeting of the Central Association of Science and Mathematics Teachers.

THESE are times when those of us who are "over here" are pushing harder on all of the home things to make up for those who are "over there," and we are coming to be glad for and to be proud of the very real part we are having in this citizens' war.

In a frank and fraternal way let me suggest to you some reasons why you should make an especial effort to attend the Eighteenth Annual Meeting of the Central Association of Science and Mathematics Teachers which is to be held at the University of Chicago on the Friday and Saturday following Thanksgiving, November 29 and 30. Candidly, most of you have put your heart's blood for years into building up the Association, and you will doubtless think of arguments which I have not. Just add them all to my simple statements and, not only come to the meeting yourself, but be a missionary to bring with you every one of your colleagues whether members or not.

In the first place the Association needs you and your strong influence at this time more than it ever has. And in the second —pardon me—you need the Association. In spite of the high cost of living and traveling we must continue the usefulness of our science and mathematics fraternity. Indeed we must go forward. Since so many of our members are "over seas" or in camps, the Association has to depend upon you loyal, faithful member, to rally even more strongly to its support, and to enlist new members. Teachers will say that they are so pressed for time, and the demands upon their salary are so heavy, that they cannot join, much as they wish to. They cannot afford not to be members. You cannot afford not to attend the Annual Meeting. Why? Let us consider the matter together.

One result of the war will be a shifting of our educational programs, standards and ideals. The Executive Committee of the Association feels that it will be justified in holding the conference this year upon one basis only; that of bringing before our members the problems which are arising in science and mathematics teaching and giving you the chance to discuss them and compare your experiences and constructive plans with those of your fellows.

Do you realize what an opportunity is ours just now? Never in all history have teachers had such a prospect for reconstruction and service in their profession. We wish for more recognition from society and adequate salaries. But we know that a far greater reward to us is the deep satisfaction which comes through having a share in the construction of pioneer things in education. Some of our country's men and women are bound to become the leaders in this vital hour. Will you be one of these creators? Will you commence now and will you bring to the Annual Meeting all of your ideas and enthusiasm?

About the first of November you will receive the Program of the Meeting. We hope you will read between the lines and realize how the addresses for the General Session and the programs for the Section Conferences are all built around the central theme—"The Educational Demands of an Awakened Democracy."

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Let me call your attention in the briefest manner to a few things in the way of illustration. The speaker upon the central theme itself is to be Andrew McLaughlin, Head Professor of History in the University of Chicago. He went to England recently at the invitation of that Government as spokesman for our country. Everyone who has heard him since his return declares he has brought back to the United States a wonderful message and that he is a most attractive and forceful speaker. By the way, we are urging our members to make a sacrifice and attend the Annual Meeting. Do not forget that our speakers and writers of papers are making an even greater sacrifice. Prof. McLaughlin is one who is coming to us in the midst of an already overcrowded schedule.

The other Friday forenoon speaker is A. Barthéleme, Consul for France. He will address us upon "Progressive Science and Mathematics Courses and Teaching in France." The Consul is a graduate of the University of Paris. He has been in editorial work, was one of the representatives from France at the World's Fair in Chicago and was Consul to Great Britain before coming to the United States.

In the evening we shall have a cafeteria dinner together at the Quadrangle Club. While about the tables the Chairman of the Committee on Science and Mathematics in the High School of Tomorrow will give his report. This will be followed by an informal discussion. When through we shall adjourn to a social hour. There we shall have the great privilege of coming into close relationship with another one of the very busy men and winners of the war, Dr. Steiglitz, Head Professor of Chemistry in the University of Chicago, who has been devoting his research and that of his whole department, which has remained intact for this purpose, to the making of war gases. He will give a very brief shop talk on "Gas Warfare" and then permit us to put to him all the questions we care to. This in itself is a rare opportunity for members of the Central Association.

An important feature of each Section program is the report by its member of the Committee on Science and Mathematics in the High School of Tomorrow. He will give the result of his study and open the discussion. Here again you will find just the material you will wish to use in your own constructive problems and personal development and leadership.

It is not possible to present, even in outline, the exceedingly attractive program which the Sections have prepared. Your Executive Committee has marvelled that men and women of such reputation could take time from their overburdened lives to come to us. It simply means that they realize what a force our Association is in building up the boys and girls of the Central States. Here is another reason why we should support the meeting and magnify its service to the science and mathematics teachers of our acquaintance.

Just a word as I close abruptly. Do you know how much it means to have fellowship with the teachers of your department? Have you felt the fraternal warmth which those of us who get together have for one another? Really this is one of the fine rewards for being a teacher. You will not find anywhere stronger, more sincere and more helpful friends. Just come open hearted, and with the determination to take an active part in the meeting, and learn for yourself how good this will be for you.

And be sure and bring all of the Science and Mathematics teachers of your territory with you. This is your privilege.

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Plan today how you will win them. It will take thought, time and work. But so does everything worth while.

Let us one and all have a part in working out "The educational demands of an awakened democracy." What a joy it will be to look back and realize that we contributed in this vital way to the final establishment of liberty and its blessings.

Yours for the Central Association,

HARRY D. ABELLS,
President.

ORGANIZATIONS UNITE FOR SERVICE.

To carry unitedly to the men in France the welfare services which during the past year have built up the morale of General Pershing's army, the seven relief organizations of the United States will conduct from November 11th to 18th the United War Work Campaign for $170,500,000. The agencies cooperating are the Young Men's Christian Association, the Young Women's Christian Association, the National Catholic War Council, the Jewish Welfare Board, the War Camp Community Service, the American Library Association and the Salvation Army. In France these several organizations have worked in closest unity and without duplication of effort among the enlisted men of the American army and navy and their allies. In their common appeal for funds, an opportunity is given for similar joint action on this side of the Atlantic. To every boy in uniform each organization through its representatives over there stretches out its home friendliness. Its clubroom is his church, his college, his library and the biggest reminder he has of home. If he is studying now for after the war, there are night classes and lectures on modern history and current events. Even into the front line trench the welfare agencies have carried their class-rooms. In giving to its activities during the war the public is already starting to meet the after-war problems.

The Young Men's Christian Association which is asking $100,000,000 for its war work, is serving no less than three million American soldiers and sailors in Europe and in the training camps at home. It has between five and six hundred huts in this country and a greater and growing number on the other side. It is keeping a bit of home even at the trenches and under the fire of the enemy. The Y. M. C. A. hut at the front is the soldier's club, his church, his college. It is open to all denominations for service, from the early mass of the Roman Catholic, to the later service of the Protestant clergyman and the Jewish Rabbi, and the song service of the Salvation Army. It is used for musical and theatrical entertainments by the most famous musicians, actors and actresses of the world. It is a place of study and lectures for the boy who would study French or other subjects to be turned to account in after-war days; it is the quiet place where the soldier reads or writes his letters home.

The Young Women's Christian Association, asking for $15,000,000 has gone into the war and into the war industries with the women and girls called to new and perilous work. It has cooperated with the government in the proper housing and care of the women munition makers in this country and has provided recreation centers at all of the twenty-one cantonments. It has established similar centers at munition plants in France and has been so successful in providing necessary rest and recreation that the English government has asked the help of the American Y. W. C. A. in work of that character in England. It has club centers in Russia at Petrograd, Moscow, and Samara, and cooyerated wth the Y. M. C. A. during the summer in an agricultural exhibit on a boat that

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plied up and down the Volga river. It has about one hundred hostess houses—"a bit of home within the camp"—erected at military camps at the requests of the commanders, and a number more are authorized and being built. It is doing work among the colored girls affected by war conditions, and among the foreign-born women whose men have gone to war.

The National Catholic War Council including the Knights of Columbus, asks $30,000,000. The Knights of Columbus have erected club houses at the points of embarkation in this country and embarkation in France, and have secretaries assigned to permanent duty aboard transports plying between this country and European ports. There is a headquarters building in Paris and permanent club houses throughout France and in London. A fleet of motor trucks follows the rapidly advancing armies to provide our soldiers with "service under fire." These trucks carry chocolate, writing material, soap and towels, and other articles.

The Jewish Welfare Board, which will receive a $3,500,000 share in the United War Work Campaign, officially represents all national Jewish organizations in building up the morale of more than one hundred thousand Jewish men in the army and navy. It has sent its trained workers into the camps and naval training stations. It has erected clubrooms to which soldiers irrespective of race can go for rest or for entertainment, where there are libraries with English, Yiddish, and Hebrew books, where religious services on Friday evenings and holidays are open to any man who wishes to attend. In the towns near the camps, community centers furnish the soldiers with social rooms and sleeping quarters. Jewish chaplains are serving with the army overseas and in the navy. Welfare workers are aiding the families left at home and among the men in the ranks are performing personal services, distributing gifts, and keeping up the boy's contact with his home.

The Library War Service of the American Library Association which is asking for $3,500,000 has sent overseas during the past year more than a million books for the men of the fighting forces. It supplies a book for the man when he wants to read and the kind of a book that he wants. It gives its service quickly and directly to the army and furnishes to the soldier who is preparing for after the war the technical books that he needs for his study. In the huts and canteens of all the welfare organizations a branch library has been established at which the soldier or sailor can pick up in his hour off duty the novel or magazine that suits his fancy. There is a deck library on every transport, and on many of the war ships and government cargo ships. In every ward of every military hospital a shelf of books is near the hand of the convalescent soldier. The boo from the home library, the magazine, the new educational or technical volume bought with money from the public, will circulate through the Association to every man in every branch of service.

The War Camp Community Service which is asking $15,000,000 is a nation-wide movement for hospitality keyed to harmonize with the training camp program of the War and Navy Departments. It has a definite, ordered program, supplemented by resources of the folks back home. It counteracts the red light lure with the greater attraction of wholesome recreation and speeds the man in khaki or blue on his overseas way with a keener enthusiasm to fight for a country in which he leaves no bitter, regretful memories. The War Department Commission on Training Camp Activities was appointed by Secretary Baker in April, 1917. The Navy Department Commission of Training Camp Activities was established by Secretary Daniels at the same time. These Commissions called on the Playground and Recreation Association of America

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which had had years of experience in this sort of thing, to carry on the work in the communities outside and adjoining the camps under the official name of the War Camp Community Service.

The Salvation Army's request for its work at home and abroad is $3,500,000. As near the trenches as relief work can be carried, the Salvation Army "hutment" is open, and a woman officer ready to serve hot food to the men under fire. A cook stove with an oven that can bake is certain to be part of the equipment of the little Salvation Army house. In front of it, "lassies" with baskets of food have stood under fire in order to give a hot cup of coffee to the men who are bringing up the ammunition. Truck loads of pies and doughnuts start daily from the bases to the extreme ends of the lines. The women officers have mended the clothing and darned the stockings of the soldiers who come to the hutment for recreation. In this country, the Salvation Army maintains hotels near the military and naval bases, and in their clubrooms entertainments fill the soldier's leisure time. Church services are held on Sundays.

CALIFORNIA COAST FOGS.

The importance of fog in navigation along the California coast is strikingly evidenced by the following fact. The Marine Exchange of the San Francisco Chamber of Commerce was asked what proportion of the shipwrecks which occur along the coast of California are due to fog. The answer was, "All of them." High winds and violent storms are rare. Fogs are the greatest danger to navigation. They are the chief contributory cause of the majority of marine disasters. Recent extensions and improvements of the fog-reporting service of the Weather Bureau have made possible a more detailed and more accurate study of fog conditions than could be made until now. Mr. Andrew H. Palmer, of the U. S. Weather Bureau at San Francisco has prepared some new statistical tables and has briefly discussed the data ("Fog Along the California Coast," *Monthly Weather Rev.*, Vol. 45, 1917, pp. 496-499).

Two types of fog have long been recognized on the California coast, summer fogs and winter fogs. In summer a fairly persistent fog bank hangs alongshore, extending seaward about fifty miles. The average vertical thickness is 1,500 feet. A vertical extent of 2,000 feet is rarely exceeded. During the summer months the excessive heating of the land causes an indraft of air from the ocean to the west. The inflowing wind reaches velocities of twenty-five or thirty miles an hour on summer afternoons near the Golden Gate. The westerly wind carries the fog onto the land, but it is usually dissolved, or becomes "high fog" or cloud before it penetrates far inland. These summer fogs seem to be due chiefly to the mixture of air masses which differ in temperature and in relative humidity. The temperature of the mixture is below the dew point, and condensation results. Along the coast there furthermore is an upwelling of cold water, similar, it may be noted, to the conditions off the coasts of northern Chile and of Peru, of northwestern Africa, and of the Somali coast. During the summer, with generally light winds, the air over this cold water is also cold and nearly saturated. The prevailing westerly winds, reinforced by the indraft towards the hot land, blow across this cold water. These westerly winds are themselves nearly saturated but are slightly warmer than the cold air with which they mix. The mixture of these two air masses, both not far from their dew points, produces the condensation. These fogs seldom produce measurable precipitation, but are of great benefit to vegetation, as, for example, to the redwoods, which are limited to a narrow coastal strip in the fog region and never extend

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more than thirty miles inland. This summer type of fog sometimes occurs in winter but is rare then because the air is cooler than the water.

Winter fogs are of land origin. They are radiation fogs. They occur in all parts of California and occasionally move seaward, without going far offshore. They are thin (100-200 feet vertical extent); occur under weak gradients; and form at night. "Tule fog" is the local name for these winter fogs in California, because they are so frequent over swamps and marshes filled with tule (Mexican bulrush). Tule fogs last until they are "burned off" by the sun or are displaced by the wind.—[R. DeC. Ward in *Geographical Review.*

HONEY PRODUCTION.

The United States Department of Agriculture estimates that the honey crop for 1918 will approximate two hundred and fifty million pounds. When it is recalled that the nectar in flowers does not become honey until it is worked over and partly evaporated by the bees, the magnitude of the labor in which they engage is apparent. These industrious insects must move fully 150,000 tons of material during the season in making the honey crop, to say nothing of the honey consumed by the bees themselves. The labor seems out of all proportion to the insect. The best all-round honey plant is reported to be the white clover. About half the honey produced is gathered from this plant. Next in importance comes alfalfa, followed closely by sweet clover. In some regions the latter is the chief honey-producer. A good deal of honey is gathered from the general run of flowers, but the plants that produce a honey that can be identified are not many. The principal species are cotton, basswood, tulip tree, buckwheat, goldenrod, and mountain sage. In the tropics the logwood, one of the legumes, produces much honey. At present, California produces about one-fifth of the honey crop. Other honey-producing states, though far behind California, are New York, Texas, Michigan, Iowa, Colorado, Wisconsin, Missouri, and Pennsylvania. —[*American Botanist.*

ECHOES OF THE WAR IN GREENLAND.

The world at war is making itself felt even in the Smith Sound region. No supplies have reached the station at North Star Bay, and nearly all the ammunition is exhausted. The Eskimos will soon be forced to resort to the primitive methods of hunting and living that they employed before the white man came with his guns, ammunition, cooking utensils, knives, matches, tea, and cloth. In Danish Greenland, where the natives have become quite dependent on the simple provisions and equipment sold them by the Royal Trading Company, the effect is even more pronounced and prospects even darker, for there the people have quite forgotten the methods of hunting employed by their ancestors and have to rely in large measure upon imported supplies.

Last year the hunt was generally poor in the northern districts, with small kills of seal and white whale, the chief resources of the Greenlanders. The summer of 1917 was an unusually severe and unfavorable season, with much snow, cloudy weather, and cold. The winter began early. As far south as Umanak sledging was possible in mid-November, so that the Eskimos could go out to set their seal nets. Heavy ice came soon afterward and did not break up again. The governor and the doctor at Upernivik, while out on a motor-boat journey, were frozen in far from the village and did not escape to return to their homes until after a month's absence.—[*Geographical Review.*

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PROPOSED AMENDMENT TO THE CONSTITUTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

It is proposed that Article IV of the Constitution be amended to read as follows:

This Association shall be divided into sections as follows: Biology, Chemistry, Earth Science, General Science, Mathematics and Astronomy and Physics.

THE THOMAS CHARLES COMPANY.

The writer of this paragraph has watched the development of this splendid company for the last thirty years with interest and pleasure. It surely is with much delight that the kindergarten world looks upon the remarkable success of this firm. They have been obliged to move their place of business several times during this period, on account of the need of more room in order to handle their ever-increasing business. They have recently moved to their new and commodious building at 2249-53 Calumet Ave., Chicago, Ill., where they will be pleased to see their friends at any time. The venerable Thomas Charles, a most remarkable gentleman with a mind as keen and active today as it was fifty years ago when he was in his young manhood, will be only too pleased to see any person who is connected with the schools in any way, shape, or manner. The genial and capable secretary and manager, William T. Dix, on whose shoulders the burden of the firm now rests, very largely, is a person who deserves all the success that has come to the company. This success is due not so much to the demand for kindergarten goods, as to the uprightness, honesty, and integrity of the firm in all its dealings. Their new building is four stories in height and has an area of 10,500 square feet on each floor. The firm is the northwestern representative of the Milton Bradley Company of Worcester, Mass. Do not hesitate to send them any order for kindergarten material. You will always be treated well.

INCREASE IN PRODUCTION OF MARL IN 1917.

The marl sold for agricultural use in the United States in 1917 amounted to 73,900 short tons, valued at $165,223, compared with 58,088 short tons, valued at $144,768, in 1916, an increase of 25 per cent in quantity and 13 per cent in value. The average price, however, unlike that of nearly all other commodities, decreased from $2.32 to $2.21 a ton.

Of the total output, 47,914 tons, valued at $112,075, or $2.35 a ton, was fresh-water marl, a calcareous ooze consisting mainly of an accumulation of small shells formed of carbonate of lime and of minute crystals deposited from the same material by the action of bacteria. This output came from nine companies—three in Virginia, two in California, and one each in New York, Pennsylvania, West Virginia, and Arkansas. The production in 1916 was 48,447 tons, valued at $126,345, or $2.60 per ton, and was made by seven companies—three in Virginia, and one in each of the other States named except West Virginia.

Marine marl, derived from fragments of marine shells, loose or partly consolidated, was produced by five companies in the Coastal Plain region of North Carolina and South Carolina, the output amounting to 25,986 tons, valued at $53,148, or $2.35 a ton, in 1917, compared with 9,641 tons, valued at $18,423, or $1.91 a ton, in 1916.

The above figures were compiled under the direction of G. F. Loughlin, United States Geological Survey, Department of the Interior, from reports of producers and in cooperation with the State Geological Surveys of New York, North Carolina, Pennsylvania and Virginia.

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ARTICLES IN CURRENT PERIODICALS.

American Botanist, for August; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "A New Form of Prunella Vulgaris," J. C. Nelson; "The Barberry and the Wheat Rust," Willard N. Clute; "Blossoms by the Wayside in the Rockies," Blanche H. Soth.

Geographical Review, for September; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "The Finn in America" (five maps, thirteen photos), Eugene Van Cleef; "On 'Savssats': A Crowding of Arctic Animals at Holes in the Sea Ice" (one map, six photos), Morten P. Porsild; "The Galapagos Islands," George M. McBride; "The Real Temperatures Throughout North and South America" (one map, twenty-seven diagrams), Mark Jefferson; "The Slavs of Northern Hungary" (three insert maps in color, one text map, one diagram), B. C. Wallis.

Journal of Educational Psychology, for June; *Baltimore, Md.; $3.00 per year, 50 cents a copy:* "Monroe's Standardized Silent Reading Tests," Walter S. Monroe; "Psychological Aspects of Language," George C. Brandenburg; "An Absolute Point Scale for the Group Measurement of Intelligence. Part II," Arthur S. Otis.

Journal of Geography, for October; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Ways of Raising Geography Teaching Above the Commonplace," Ona I. Nolan; "Cities in Spain," Frederick Homburg; "The Reef-Encircled Islands of the Pacific (Continued)," W. M. Davis.

National Geographic Magazine, for July; *Washington, D. C.; $2.50 per year:* "New York—Metropolis of Mankind" (thirty-nine illustrations), William J. Showalter; "Under the Heel of the Turk" (fourteen illustrations), William H. Holt; "A Day in the Geographic Words" (eight illustrations), Carol Corey.

Photo Era, for September; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Camouflage-Effects—Their Relation to Photography," William S. Davis; "Price Hires a Model," Frank King; "Pictorial photography as I See It (In Three Parts—Part II)," C. W. Christiansen; "Are Lenses Fairly Marked?" R. Child Bayley; "Better Pictures for the Nature-Lover," Bertran F. Hawley; "Enter—Professor Pyro," Michael Gross.

Physical Review, for October; *Ithaca, New York; $6.00 per year, 60 cents a copy:* "On the Variations of the Photo-electric Current Due to Heating and the Occlusion and Emission of Gases," L. A. Welo; "Electric Force on the Mercury Arc," C. D. Child; "Effects of Dielectrics on the Sparking Voltage," E. R. Wolcott; "On the Effect of a Transverse Magnetic Field on the Discharge Through a Geissler Tube," James E. Ives; "The Diffraction of Light by an Obliquely Held Cylinder," T. K. Chinmayanandam; "The Effect of Gases and Metallic Vapors on the Electrical Properties Exhibited by Selenium Crystals of the Hexagonal System," W. E. Tisdale.

School Review, for September; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Progressive Requirements in American History for Junior and Senior High Schools," Committee on History and Social Studies; "Supervised Study in the University of Chicago High School," G. L. Harris; "The Teaching of Civics," Charles H. Judd.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

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Lists of questions are acknowledged from G. H. Stone, Lawrenceville, Ill. This contribution from Mr. Stone reminds the Editor that he has received very few questions from State Examining Boards. From each state will some *two or three* make themselves committees to forward such material?

Science Tests.

The Editor still promises further tests. Make suggestions.

Walter N. Lacy, Anglo-Chinese College, Foochow, China, sends in a partial report on physics tests.

G. H. Stone, Township High School, Lawrenceville, Ill., asks to be enrolled among those interested.

Tests on mechanics and on chemistry will soon be prepared and mailed to all who are on the list. Your assistance will be greatly appreciated.

QUESTIONS AND PROBLEMS FOR SOLUTION.

309. *Proposed by Franklin T. Jones.* (The readers of SCHOOL SCIENCE AND MATHEMATICS have ideas as to *Science in the High School of To-morrow. Please send in these ideas as soon as you receive this journal.*)

(*a*) What should be the science in the high school of tomorrow?

(*b*) What immediate modifications of our science work should be introduced to meet the present emergency in education?

(*c*) Should these modifications become fixtures?

(*d*) What modifications have you already introduced?

Please answer very promptly.

The following questions are contributed by Mr. G. H. Stone, Lawrenceville, Township High School, Lawrenceville, Ill.

(Minnesota readers will please notice and send other lists to the Editor.)

MINNESOTA STATE HIGH SCHOOL BOARD.

May Examination of 1918.

Answer questions in the order given. Put down the number of the question and its credits whether you answer it or not. The time for writing this examination is two hours.

CHEMISTRY—MONDAY, MAY 27, 2 P. M.

(*Answer Any Five.*)

1. Laws. Give: (*a*) (5) the law of Charles; (*b*) (5) the Law of Definite Proportions; (*c*) (5) the Law of Multiple Proportions; (*d*) (5) Avogadro's Hypothesis.

2. Laboratory Preparations. Describe any two, giving equations: (*a*) (10) the preparation of carbon dioxide; (*b*) (10) the preparation of chlorine; (*c*) (10) the preparation of ammonia.

3. Formulas. Write the chemical formulas for any five of the following compounds: (*a*) (4) cane sugar; (*b*) (4) ethyl alcohol; (*c*) (4) saleratus; (*d*) (4) acetic acid; (*e*) (4) calcium carbonate; (*f*) (4) ammonium sulphate; (*g*) (4) acetylene.

4. Tests. Describe any two: (*a*) (10) a test for the presence of soluble chlorides; (*b*) (10) a test for the presence of soluble sulphates; (*c*) (10) Fehling's test for sugar.

5. Problems. Solve any two:

(*a*) (10) What is the percentage composition of potassium nitrate?

(*b*) (10) How much hydrogen by volume can be made from water and 100 grams of metallic sodium?

(*c*) (10) A gas measures 650 cc. at 755 mm. and 70° C. Find the volume at 760 mm. and 0° C.

6. War Chemistry.

(*a*) (12) Discuss the chemical composition of fats, sugar, lean meat, and war flour, and state for each how it helps to run the human mechanism.

(*b*) (6) What is the approximate chemical composition of smokeless powders and of trinitrotoluol?

(*c*) (2) Why do these compounds explode readily?

7. Chemical Terms. Define and illustrate five of the following:

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(*a*) (4) synthesis; (*b*) (4) acid; (*c*) (4) salt; (*d*) (4) fermentation; (*e*) (4) atomic weight; (*f*) (4) valence.

8. Chemical changes. Describe, preferably with equations, what occurs chemically in four of the following: (*a*) (5) action of baking powder in cooking; (*b*) (5) lighting of a match; (*c*) (5) explosion of methane, CH_4, in coal mines; (*d*) (5) formation of starch in leaves of plants; (*e*) (5) blackening of silverware; (*f*) (5) setting of plaster of Paris.

PHYSICS—MONDAY, MAY 27, 2 P. M.

1. (20) Define or explain any five: (*a*) weight; (*b*) Northern lights; (*c*) astigmatism; (*d*) acceleration; (*e*) convection currents; (*f*) quality of sound; (*g*) electrolysis; (*h*) efficiency of a machine.

2. (20) State a practical application of the following laws: (*a*) Joule's Law for the quantity of heat developed in a conductor carrying a current of electricity; (*b*) Hooke's Law; (*c*) Law of Levers; (*d*) Law of Centrifugal Force.

3. (20) State in a sentence or two, the use you made of five of the following instruments in your laboratory: (*a*) tuning fork; (*b*) caliper; (*c*) galvanometer; (*d*) rheostat; (*e*) hydrometer; (*f*) calorimeter; (*g*) siphon; (*h*) induction coil.

4. (20) Give in detail how you worked out any two of the following problems in your laboratory: (*a*) specific heat of any metal; (*b*) electrical resistance of a coil of wire or of some instrument; (*c*) the magnifying power of a simple lens; (*d*) the verification of Boyle's Law; (*e*) the density of a solid lighter than water.

5. (20) Solve any two of the following:

(*a*) How many horsepower are there in a waterfall of 30 ft., if 1,000 cu. ft. of water pass over it in a minute?

(*b*) What is the power of a dynamo if it produces 20 amperes of current at 110 volts?

(*c*) Find the cost of running a washing machine of one-half horsepower motor for 3 hours, if the cost of electricity is 8 cents per K. W.

(*d*) What mass of water at boiling point will just melt 25 K. G. of ice at 0° C.?

(*e*) How far above the earth is an airplane from which a bomb is dropped, if the bomb strikes the earth in fifteen seconds?

6. (20) Explain any five of the following: (*a*) photography in the manufacture of expensive books; (*b*) why boys in playing prefer a steel ball as a "shooter"; (*c*) the effect of expansion and contraction in the deterioration of building structures; (*d*) the use of the hydraulic ram on the farm; (*e*) air cushions in sudden water pressure changes; (*f*) what simple machine you are making use of in sweeping with a broom; (*g*) the occurrence of osmotic pressure in nature; (*h*) why "hearing" is so easily injured in warfare; (*i*) why binoculars are in such demand at present.

PRODUCTION OF PLATINUM IN THE UNITED STATES IN 1917.

According to figures compiled by J. M. Hill, of the United States Geological Survey, Department of the Interior, only 605 ounces of crude platinum was sold by placer mines in 1917. This is less than the sales in 1916 by about 100 ounces. The imports of crude platinum amounted to 31,921 ounces, not counting the 21,000 ounces of Russian crude platinum which was received by the Government late in December.

During 1917 refiners made about 33,000 ounces of platinum, 4,800 ounces of palladium, 833 ounces of osmiridium, and 210 ounces of iridium, which can be called "new metals." Of this amount about 7,400 ounces probably originated from domestic materials.

The saving of scrap platinum of all classes resulted in much larger recoveries of secondary platinum metals than in previous years, a total of 72,000 ounces being recovered, as compared with 48,000 ounces in 1916.

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PROBLEM DEPARTMENT,

Conducted by J. O. Hassler.
Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, comp'eteness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2501 W. 110th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

566. *Proposed by R. T. McGregor, McArthur, Cal.*

Solve the equation

$$\sqrt[4]{x+27}+\sqrt[4]{55-x}=4.$$

I. *Solution by R. M. Mathews, Duluth, Minn.*

Put $u^4=x+27$, Then $55-x=82-u^4$

and the given equation becomes

$$\sqrt[4]{82-u^4}=4-u$$

$$\therefore 82-u^4=256-256u+96u^2-16u^3+u^4$$

or $u^4-8u^3+48u^2-128u+87=0$.

The roots of this equation are

$$u=1,\ 3,\ 2+5i,\ 2-5i.$$

whence $x=-26,\ 54,\ 14-840i,\ 14+840i$.

Each of these roots checks.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

$$\sqrt[4]{x+27}+\sqrt[4]{55-x}=4$$

Raising to 4th power and factoring we have

$$(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}[2((27+x)^{\frac{1}{4}}+(55-x)^{\frac{1}{4}})^2-(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}]=87$$

or $(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-32(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}+87=0$

$$[(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-3][(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-29]=0$$

$$\therefore (27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-3=0 \text{ and } (27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-29=0$$

whence $x^2-28x-1404=0$ and $x^2-28x+705796=0$

and $x=54$ or -26 and $x=14\pm840i$.

The roots of $x^2-28x+705796=0$ are redundant.

III. *Solution by Philomathe, Montreal, Can.*

Let $\sqrt[4]{x+27}=y$ and $\sqrt[4]{55-x}=z$.

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Then we have the system: $y+z = 4$ (1), $y^4+z^4 = 82$ (2),
square (1), $y^2+z^2+2yz = 16$ or $y^2+z^2 = 16-2yz$ (3),
square (3), $y^4+z^4+2y^2z^2 = (16-2yz)^2$ (4),
(2) and (4) give $82+2y^2z^2 = (16-2yz)^2$ (5),
(5) is a quadratic equation in yz. Its roots are 3 and 29;
The system $y+z = 4$ and $yz = 3$ gives $y = 3$, $z = 1$, hence $x = 54$, or $y = 1$, $z = 3$, hence $x = -26$;
The system $y+z = 4$ and $yz = 29$ gives imaginary roots.

These roots are $y = 2\pm5i$ and $z = 2\mp5i$;
for $y = 2+5i$, $x = (2+5i)^4-27 = 14(1-60i)$,
for $y = 2-5i$, $x = (2-5i)^4-27 = 14(1+60i)$.

The roots are 54, -26 and $14(1\pm60i)$.

Solutions were also received from NELLIE F. HENDERSON *and* ROXANNA E. SPILLER.

Geometry.

567. *Proposed by N. P. Pandya, Sojitra, India.*

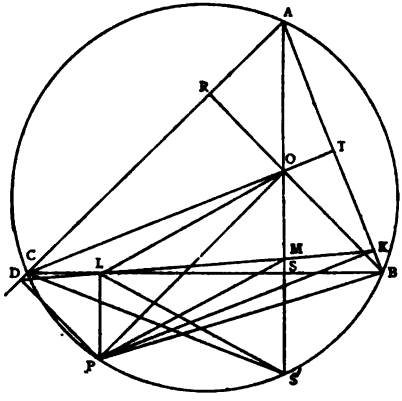
Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

A note on this will be published in the next issue.—*Editor.*

568. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

The line that joins the orthocenter of a triangle to any point on the circumscribed circle bisects the line joining the feet of the perpendiculars dropped from this point upon the three sides of the triangle.

Solution by Nelson L. Roray, Metuchen, N. J.



Let ABC be the given triangle, O the ortho-center, P any point on the circumcircle, PD⊥AC, PL⊥CB, PK⊥AB, AS⊥CB, BR⊥AC, CT ⊥AB, S′ point on circle where AS intersects circumference, DLK Simson's Line intersecting AS at M.

Then OS = SS′
also P, L, K and B are concyclic
$\therefore \angle PKL = \angle PBL = \angle CS'P$
$\angle SMK = 360-(180+\angle PKL+\angle SBA)$
$= 180-(\angle PKL+\angle SBA)$
and $\angle SML = \angle PKL+\angle SBA = \angle PS'A$.
$\therefore$ PLMS′ is an isosceles trapezoid.

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and PM = $\angle S' = \angle O$

$\therefore \angle COL = \angle CS'L$ ($\triangle COL \cong \triangle CS'L$)

$\therefore \angle MOL = \angle PMS' = \angle MS'L$

and LO || PM

and PO is bisected by DLK.

Note: PO does not bisect Simson's Line nor can it, since the line is a straight. PO bisects certain parts of it, e. g., LM in the above.

Also solved by Philomathe.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC, respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

No solutions of this problem have been received. The editor will consider it in the next issue.—*Editor.*

Trigonometry.

570. *Proposed by R. T. McGregor.*

Find θ when

$$\frac{\tan^2\theta+\sec^2\theta}{\csc\theta-\operatorname{ctn}\theta} = \frac{1}{3}.$$

Solution by Philomathe, Montreal, Can.

Let $\tan\frac{\theta}{2} = x$, then $\sin\theta = \frac{2x}{1+x^2}$ and $\cos\theta = \frac{1-x^2}{1+x^2}$,

the given equation becomes

$$\frac{\left(\frac{2x}{1-x^2}\right)^3+\left(\frac{1+x^2}{1-x^2}\right)^3}{\frac{1+x^2}{2x}-\frac{1-x^2}{2x}} = \frac{1}{3},$$

or, after a few transformations,

$$x^5+x^4-6x^3+20x^2-7x+3 = 0.$$

By Sturm's theorem, we see that this equation has but one real root. and it is between -3 and -4. By Horner's method, I found $x = -3.93911$, hence $\operatorname{tg}\theta/2 = -3.93911$, and $\theta/2 = 104°14'40''$, or $\theta = 208°29'20''$.

Note. The general solution is $n.360° + 208°29'20''$.

Late Solutions.

558. *Angus McLeod, Aberdeen, Scotland.*

Answers to Queries.

Concerning certain objections to proofs of problem 554, which was published in May, the editor wishes to say that although solutions II and III are not worked out in detail, to save space, it is true that when the proper algebraic reductions are performed the result may be stated in a manner similar to that used in solution VI at the close. The solver of III suggests that $(a^2+b^2-c^2)/2ab$ be substituted for cosC in performing the reduction. *It must be remembered that a, b, and c are positive values by the nature of the problem.*

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PROBLEMS FOR SOLUTION.

581. *Proposed by A. MacLeod, Aberdeen, Scotland.*

The six straight lines which trisect the angles of a triangle meet in three points which form the vertices of an equilateral triangle.

Could four equilateral triangles be found determined by the twelve interior intersection points of these six lines?—*Editor.*

582. *Proposed by A. MacLeod.*

A and B are two points outside a circle unequally distant from the center. Find the point C on the circle such that AC+CB is a minimum.

583. *Proposed by Norman Anning, France.*

Solve the triangle, $a = 181$, $A = 120°$, $b-c = 1$.

584. *Proposed by Norman Anning.*

AD, BE and CF are the medians of the triangle ABC; show that $\cot ADB+\cot BEC+\cot CFA = 0$.

585. *Proposed by Norman Anning.*

Eliminate θ from the equations

$$x = \cos 2\theta+2\cos\theta,$$
$$y = \sin 2\theta-2\sin\theta.$$

BIRDS HELP SCHOOL GROUNDS.

HOW AND WHY THEY SHOULD BE ATTRACTED TO THE YARD OR CAMPUS.

Birds have such an important part in the courses of nature study given in most schools and colleges that more should be done, according to the United States Department of Agriculture, to attract them to school grounds or campuses.

Unfortunately, says the department, the campus, like the park, has suffered from too formal landscape gardening. Cropped hedges are not inviting to the birds, and wooded campuses where formerly birds abounded have been so filled with buildings, so gardened and formalized that birds are now scarce. Some corner—preferably of original woodland and undergrowth if that still exists—should be set aside and allowed to run wild, as a bird sanctuary.

BIRDS AN EDUCATIONAL RESOURCE.

In addition to the help that birds give as protectors of trees and shrubbery against injurious insects, they furnish, on school grounds, a distinct educational resource. There is scarcely an advanced school in the country that does not offer courses in bird study; and the study of birds out of doors is a necessary supplement to that in classroom and laboratory. For this reason, says the department, the educational need should be kept in view by those in charge of college and school grounds.

Plants which furnish bird foods should be added, nest boxes put up, and winter feeding carried on as an interesting and instructive part of the work in bird-study classes. It is further suggested that the teacher of ornithology should be called in to advise in relation to the planning and treatment of the campus.

Those who are interested in attracting birds to public and semipublic reservations can get a publication devoted to this subject by writing to the United States Department of Agriculture at Washington for Bulletin 715.

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BOOKS RECEIVED.

Census of the Virgin Islands of the United States, by Eugene F. Hartley. 174 pages. 15x23 cm. Paper. 1918. Government Printing Office.

Airplane Characteristics, by Frederick Bell, Cornell University. Pages v+123. 16x23 cm. Cloth. 1918. $1.60 net. Taylor & Company, Ithaca, N w York.

Petroleum; A Resource Interpretation, by Chester G. Gilbert and Joseph E. Pogue, United States National Museum. 81 pages. 15.5x24.5 cm. Paper. 1918. Government Printing Office.

Ontario High School Laboratory Manual in Chemistry, by George A. Cornish, University of Toronto, and Arthur Smith, Central Technical School, Toronto. Pages vii+135. 12.5x19 cm. Cloth. 1917. 25 cents. The Macmillan Company, Toronto.

Ontario High School Chemistry, by George A. Cornish, University of Toronto, and Arthur Smith, Central Technical School, Toronto. Pages vii+297. 12x19.5 cm. Cloth. 1918. 50 cents. The Macmillan Company, Toronto.

Essentials of Modern Chemistry, by Charles E. Dull, South Side High School, Newark, New Jersey. Pages ix+458. 13.5x19.5 cm. Cloth. 1918. Henry Holt & Company, New York City.

General Science Manual, by Leland R. Thompson, High School, East Chicago, Ind. Loose-leaf. 101 experiments. 21x27 cm. Atkinson, Metzger & Company, Chicago.

BOOK REVIEWS.

General Science Manual, by Leland R. Thompson, High School, East Chicago, Ind. Loose-leaf. 101 experiments. 21x27 cm. Atkinson, Metzger & Company, Chicago.

A splendid, practical, and up-to-date manual on general science. A book that can work into almost any laboratory and be used with any text on this subject. It deserves a wide and extensive sale. C. H. S.

Economy in Food, by Mabel T. Wellman, Indiana University. 36 pages. 13x19 cm. Cloth. 1918. 30 cents net. Little, Brown & Company, Boston.

A remarkable little book which ought to be in the possession of every housekeeper and person who buys food for the family or restaurant. In a small space rules and advice are given on economy in buying, economy in storing food, economy in planning meals, economy in the use of leftovers, and economy in fuel. There is a splendid table of cost of one hundred calorie portions of foods and factors for calculating them.

C. H. S.

Second Course in Algebra, by Herbert E. Hawkes, Colorado University, William E. Lobe, Kansas City Polytechnic High School, and Frank C. Touton, Central High School, St. Joseph, Mo. Pages vii+277. 13x19 cm. Cloth. 1918. $1.00. Ginn & Company, Boston.

This is a revision of a well-known and widely circulated text. It has been considerably simplified, and some chapters have been omitted in accordance with the present tendencies to dismiss from school courses those that are nonessential. In the place of these omitted chapters the emphasis is put on the material which is of everyday and lasting importance. The exercises, of which there are a large number, are practically new, and many of them are for oral use. Instructors will find this as nearly perfect a text in algebra as it is possible to produce. C. H. S.

Elementary General Science, by Daniel R. Hodgdon, Normal School, Newark, N. J. Pages xxii+553. 15x20.5 cm. Cloth. 1918. Hinds, Hayden & Eldredge, New York City.

This remarkable book has been written for use in the seventh and eighth

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grades and the first years of the junior high school. It is one of the very latest books on general science, and without question is one of the best texts lately put on the market in this subject. The volume is written in a most fascinating style, and in such a manner as will appeal to the interests of the young mind. The author has distributed the amount of matter over the various sciences that are discussed, very uniformly, giving each science, as he understands it, its fair proportion of space. He has made good use of books and matter bearing upon the subjects treated in the text, and has given due credit. He is very wise in the selection of the 395 cuts and illustrations, many of which are new and to the point. The chapter on "Nostrums" is peculiarly apropos. Too much cannot be said in praise of the volume, and it undoubtedly will receive a very large adoption. C. H. S.

The Organization of Thought, by A. N. Whitehead, Trinity College, Cambridge. Pages vii+228. 14.5x22.5 cm. Cloth. 1917. $2.00. J. P. Lippincott Company, Philadelphia.

This volume is a compilation of discourses which were delivered by the author on various occasions. The book treats of the idea of thought as presented in the eight addresses included in the book. A common line of thought or reflection extends through the book. The fact that the discourses are given in an informal way makes it of a more practical value to the everyday reader than if the talks were of a more technical nature. The author is well informed on the results of the events that are now transpiring in Central Europe, and he has brought his thought into connection with the general reformation of all activities which must necessarily follow the conclusion of this great war. From cover to cover there are many suggestions that will meet the approval of the reader. The book is mechanically well made, and is printed on thick, uncalendered paper, in heavy, doubl spaced type, making it very easy to read. The volume should have a wide circulation. C. H. S.

Elements of General Science, Revised Edition, by Otis W. Caldwell, Teachers College, Columbia University, and William L. Eikenberry, University of Kansas. Pages xii+404. 13.5x20 cm. Cloth. 1918. Ginn & Company, Chicago.

This revised edition of a splendid book has been brought up to date, and in this treatment of the various subjects the authors have, if possible, improved upon the excellent first edition. There is nothing of a detrimental nature that can be said concerning this most excellent book. It is the result of many years' experience in the instruction of secondary pupils by these two most competent authors, and that which they present in this volume is authoritative, accurate, and to the point. The 181 cuts and illustrations have been selected with a view to illustrating directly the material treated in the text. The authors' study of the general science situation of the United States has been of such a character that they have been able to produce a book which can be used without any difficulty in any part of the country. Doubtless the new edition will have as wonderful a sale as the first edition had. School men will make no mistake in adopting this book for their classes. C. H. S.

Essentials of Physics for College Students, by Daniel W. Hering, New York University. Pages x+367+31. 15x22.5 cm. Cloth. 1914. $1.75 net. D. Van Nostrand Company, New York City.

This is the second edition of this most excellent text in physics, and is the outgrowth of a series of lectures which the author delivered before the undergraduate students of New York University. There are a number of changes made in this edition over the first one, and in every case the change has been for the better. It has been the object of the author to produce a book in reasonably complete form, so that the ordinary man

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may be able to secure technical knowledge of physics without becoming an expert engineer. Some of the cuts might have been improved upon, but this fact does not in any way injure the nature of the text. The book consists of seven chapters, the major paragraphs of which begin with bold faced type. At the close of each chapter there are many experiments given which are discussed in the body of the chapter. There are several tables of physical constants appended. There is a splendid index of seven double column pages. The volume is worthy to be in the library of every physicist and technical man. C. H. S.

Airplane Characteristics, by Frederick Bell, Cornell University. v+123 pages. 16x23 cm. Cloth. 1918. $1.60 net. Taylor & Company, Ithaca, New York.

Whenever anything new appears in science, or whenever a change in the world's history is brought about, books are bound to appear discussing this phase of progress. This is one of the first books that have b en produced on aeronautic which it is possible for the ordinary layman to read and understand, for an extended knowledge of mathematics is not necessary to the reader. The volume is written by a past master in the theo y of airplane characteristics. The author has produced a book from his fund of knowledge which is second to none in excellence. The cuts and diagrams are selected to show just what the author discusses. It is a text that ought to be familiar to every person in this country who is in any way connected with the aviation corps of the United States Government. There are four appendices, the first being a complete glossary of terms used in aviation. The others are of a more technical nature. Physics teachers in schools and colleges should send for a copy of the book. C. H. S.

The Vo ational Education of Girls and Women, by Albert H. Leake, Inspector of Manual Training and Household Arts, Ontario, Canada. Pages xix+430. 13x19.5 cm. Cloth. 1918. $1.60. The Macmillan Company, New York City.

This book has been prepared in a great measure for the large number of instructors who are engaged in the teaching of our pupils in the lower schools. It is intended likewise to appeal to students in normal schools and colleges who are preparing themselves to become teachers of vocational instruction of girls and women. The author does not attempt to discuss any detail of industrial occupation which is not open to women, but he bears down heavily on the way in which girls and women should be instructed in order to be able to earn a livelihood in any vocations which they may feel themselves competent to follow. The book is the result of many years' experience in practical manual training, household scienc3, and industrial education in general. There are fourteen chapters, each of which is divided into many important topics. The major paragraphs have the subject of the discussion printed in bold faced type. The volume is interesting to read, not only for he teacher but for the ordinary lay-woman. It is printed in 10 point type, on uncalendered paper, thus reducing the glare o reflection to a minimum. The half tone illu trations have been selected with care. There is a bibliography appended, and there is also a complete double column index of ten pages. The book deserves a wide circulation. C. H. S.

Mammalian Anatomy, with special reference to the Cat, by Alvin Davison. Ph. D., third edition, revised by Frank A. Stromsten, D. Sc. 115 illustrations. 243 pages. 14×20 cm. P. Blakiston's Son & Co. $2.00 net.

As indicated above, this is a revised edition of a standard work. The

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authors say with truth that "the great value of this manual has been its usable size and its concise elementary nature." They might have added that it is well and clearly written and planned and copiously illustrated. The title gives a correct idea of its scope. A good book.

W. W.

Principles of Economic Zoology, by L. S. and M. C. Daugherty. Second edition revised. 301 illustrations. 428 pages. 14×20 cm. W. B. Saunders Company. $2.00 net.

The first edition was reviewed in the columns of this magazine on its first appearance. As this edition has made few changes, it will not be necessary to go into details. The writer of this review could never understand why the title "Economic Zoology" was given to the book, for there is certainly no great amount of economic matter in the book. It seems to us that the natural history of animals, however, is an especially strong feature of the book. For schools which need this side of the work, as, perhaps, state normal schools, this book should present a strong appeal. It is a good book of its type and useful as a reference book in the high school classroom as well as a text for certain types of schools.

W. W.

Agricultural Bacteriology, by H. W. Conn, Ph. D., third edition revised by Harold Joel Conn. 63 illustrations. 357 pages. 14×20 cm. $2.00 net. P. Blakiston's Son & Co.

Owing to the author's death the revision of this book has been undertaken by another to bring the work up to date with more recent discoveries, especially in the lines of soil bacteriology, control of milk supplies and plant diseases. Professor Conn's books are always well written and especially notable for their clearness of diction. These good qualities have been retained in the revision.

The book is divided into five parts and after two chapters of a general and introductory nature there follow chapters on "Bacteria in Soil and Water"; "Bacteria in Dairy Products"; "Relation of Microorganisms to Farm Products"; "Parasitic Bacteria" and an appendix of laboratory directions. The treatment is non-technical and the style so clear that these important topics may be read and assimilated by the practical worker as well as by college students for whom the book is written. It is impossible in a brief review to give an adequate idea of the many good features, but a few may be mentioned. Throughout the work, but more especially following the more scientific exposition of a topic, the practical farm aspects of the topic are brought out. Some of the more important topics treated are those of organisms of the soil and of milk and their various applications. Knowledge of soil life is of vast importance to agriculture, and its importance can hardly be overestimated. Books which put this knowledge in form for wider circulation are especially valuable.

W. W.

Exercise and Review Book in Biology—New World Science Series, by J. G. Blaisdell, Yonkers High School. 152 pages. 20×26 cm. 21 illustrations. 80c. World Book Company.

This book is planned by the author to be a "laboratory guide, a notebook and a review book" for student use in the high school. The guide consists of directions for performing the experiment or other work of the lesson, followed by questions for observations and conclusions. All questions are followed by blank lines for an answer. Occasionally there are blanks for drawings, while at other times the drawings are already made for the pupil with letters for labelling the parts. The teacher supplies the material, the pupils answer the questions, doing whatever obser-

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vation or thought work the questions require. The course included is fairly comprehensive, covering plants, animals and human physiology. The book is written especially for New York schools.

Such a scheme may be the best that can be done for schools with poorly trained teachers and large classes, or where the teacher is burdened with too many subjects. However, it should be the last resort, for it is bound to kill initiative in both teacher and pupil. Any course in biology, while including the great fundamentals of the subject, should be made to fit the local environment of the school as well as adapted to the pupils, the equipment and the teacher himself. Stereotyped sets of questions must inevitably lead to formality and stiffness in the course unless the teacher is unusually resourceful.

W. W.

The Teaching of Agriculture, by Aretas W. Nolan, University of Illinois. 277 pages. 12×19 cm. $1.30. Houghton Mifflin Company.

Agriculture, as a part of the curriculum of high schools, is a very new subject. Like all new subjects, its teaching methods are somewhat unorganized. It takes many years to standardize the methods of teaching a subject so that the best results may be obtained. However, agriculture is making rapid progress toward better and more systematic methods. This progress is helped along in this case by the very many excellent texts that have come off the press in the last year or two. But textbooks are not all that is needed, for each book covers only a portion of the field. We needed something that would give a broader outlook and the proper proportions and setting of each branch of the subject.

This organization of the field Professor Nolan has attempted in his "Teaching of Agriculture." It will not only be a source book of suggestions for the courses in agriculture but it is to be hoped it may aid in a better organization of the courses of study offered. There has been much perfunctory and consequently poor work in the teaching of agriculture, due to lack of standardization. There being no standard of attainment teachers, often overloaded with several subjects, have been tempted to be content with a very inadequate output.

Of course, no sensible teacher will think of attempting to use the outlines the book offers bodily without change. Courses of study and the curriculum itself should be adapted to and built to suit the needs of that particular school and neighborhood. The book contains a great abundance of outlines of courses, suggestions, data and various other helps for the teacher. The advice for the teacher appears always sound and well taken. We trust that every teacher of agriculture may have opportunity to read and use the book.

W. W.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become one year old.

American Association for the Advancement of Science.

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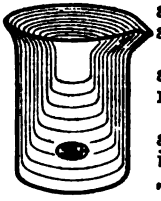

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RADIUM LUMINOUS COMPOUNDS.

The use of radium luminous compounds has only recently been recognized in connection with commercial apparatus, but is now widely known through the enormous sale of watches and clocks with "radium dials." It was as recent as 1910 that Marsden made the first measurements of the brilliancy of zinc sulphide under the action of the radiations from radium products, but it was not until several years later that advantage was taken of this fact to make instruments, which must be read at night, self-luminous.

Radium luminous compounds consist almost exclusively of specially prepared zinc sulphide, with which is mixed about four parts per 10,000 of radium bromide or its equivalent in gamma ray activity. To apply the paint, in practice, the powdered material is mixed with a minimum possible quantity of varnish or other suitable binding material, and laid on either with a brush or by filling in the figuring which has been engraved into the surface of the object to be painted. The luminosity of the material is due to the action of α = particles from the radium impinging on the crystals of zinc sulphide. The light is of a decidedly greenish hue and in the visible region lies between $\lambda = 5{,}920$ and $\lambda = 4{,}250$, with a fairly sharp edge toward the red. The degree of brightness is of the order of 10 microcandles per square centimeter, or .03 equivalent foot-candles.[1] This is about one-hundredth of the brightness of a newspaper satisfactorily illuminated for comfortable reading by artificial light. It is of the order of the brightness of white paper illuminated by the light of the full moon.

The luminosity of radium compounds falls off with time. The radium itself decays to half its value in about 2,000 years, and it has sometimes been assumed that radium paint will retain its luminosity for a similar period. But this is not the case, for decay is mainly due to action on the zinc sulphide itself, which loses its power to luminesce in the course of time. In general, the material attains a maximum brightness in ten to twenty days after mixing. The intensity then falls off gradually and probably becomes almost constant after a couple of years. Thus we may conclude that a watch dial which is satisfactorily brilliant after a year or two will continue to remain so.

When the material is applied as paint the rate of decay of luminosity is noticeably lower than that of the compound before application, and the initial luminosity is also smaller, being of the order of one-third to one-fourth of that of the compound before application. The reason for this is not clear, but it seems reasonable to suppose that the effect of the varnish or other medium is to impede the activity of the α = ray bombardment from the radium, and in this way cause an effective lowering of the radium content of the compound with a subsequent reduction of both the initial luminosity and also the rate of decay.

The initial brightness is in the ratio of the radium content, but the rate of decay of the compound of smaller content is slower, so that the ratio of the luminosities gradually approaches unity as time goes on. This question is of considerable commercial importance, for it is clear that if the compound is required for use after the lapse of several years, there is very little advantage, except from the point of view of initial brightness, in increasing the radium content beyond a certain point. For painted dials the maximum useful content for a life of over six months will not be more than .6 mg. per gram, and the minimum useful content about .2 mg. per gram. The factor of cost cannot be ignored for a compound containing .4 mg. of radium per gram of zinc sulphide costs about $30 to $35 per gram. This is mainly due to the amount of radium present.

[1] This unit is the brightness of a perfectly diffusing surface with a coefficient of reflection of 100 per cent when illuminated to an intensity of a one foot candle, i.e., by a source of one candle placed one foot away.

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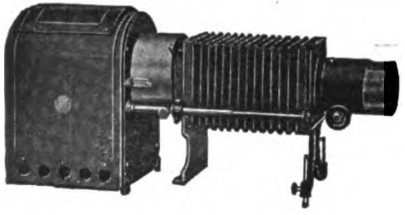

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 9 DECEMBER, 1918 WHOLE No. 155

A MORALITY CODE.[1]

BY CHARLES H. SMITH,
Hyde Park High School, Chicago.

PART I.

For Children in the Adolescent Period.

In the proper training and development of the young mind there are certain fundamental principles which must be thoroughly understood by parent and teacher in order that the youth may receive the instruction in a manner that is practically unconscious to him, and yet in one that will cause him to grasp and appreciate them in such a way that they will become a part of his higher nature. It is the purpose of the writer to present in this code a series of fundamental principles to which an intelligent person can take no exception. These are suggestions which, if presented by a tactful parent or teacher and fully grasped by the child, will drive home truths in such a manner that the young person will absorb them with very little antagonism and will cause him to grow from youth into manhood developing that highest type of citizen, which will be of immeasurable worth both to home and country.

The child should be taught to realize that the parent and teacher are his best and truest friends, and that, that in which they instruct him is for his good and prepares him to meet life's activities.

The habit of cleanliness in all its phases should be urged upon the young mind, as many of the fundamental principles which he should understand are intimately associated with the prin-

[1]One of fifty-seven Codes written by as many persons selected from nearly every state in the Union from the ranks of those known to be successful in the government and education of large groups of boys and girls. The author of this particular Code invites from everyone interested in the proper education and development of the American boy and girl, criticism and suggestions for its revision and improvement. He will thank the readers for a thorough and frank discussion of the merits or demerits of the paper.

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ciple of cleanliness, not only of body but of thought and action as well. The degree of morality possessed by these young people is largely measured by their personal appearance, and though we may not go into detail, it is enough to suggest that they must have clean hands, clean nails, clean teeth, and other conditions which will commend themselves to the teacher and parent. These physical characteristics will inevitably lend a strong influence in producing within the young person's mind clean thoughts, from which will come clean speech.

Fundamentally the child should be brought to realize that there is within him a principle of honor which he himself must develop, not only to assure self-respect, but also to merit the respect of his associates. He must, in all of his dealings with his playmates, teachers, or parents, realize that honesty is paramount to any underhandedness that he might conceive would temporarily aid him in securing favor, position, or accumulation of wealth. He should also be made to understand that it is a function of his nature to assist his playmates, especially those who are weaker in mentality or in physical prowess, thus creating within him the spirit of lovableness to such a degree that it will become second nature to assist any who might be in need of help.

The adolescent child should be taught fairness in his play, whether in various recreations or in the game of his home and social life. He must play the game for its worth, and under no circumstances strive to win by any method of an underhanded nature. If in the family there are brothers and sisters, the spirit of filial love should be cultivated to its fullest extent, that they may be mutually helpful, not only within the family circle but in all undertakings where the interests of each or any are at stake.

Love and respect for parents should be of such a deep and abiding type that, whatever the situation, the child will adhere to their teachings. There are times in the life of the young boy and girl when they need a confidant. That confidant should be a parent, or ofttimes a teacher. This highly developed respect for parents and teachers will be one of the strongest faculties in holding the child to that way of living which develops the highest moral character. Honest respect for parents develops respect for neighbors, for the community, and for the property of others.

Respect by precept and example cannot be too early incor-

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porated in the young mind. First, that for his elders should be so thorough and so complete that not only their instruction should be taken without question, but the experience and knowledge of those of superior environment and personality should be freely sought, that the younger generation may improve upon the unintentional mistakes of his predecessors.

The spirit of loyalty and honor to his school should be early created in the young mind, and should be of such a high nature that it will develop within him a desire to secure the best that that school can afford, and as advancement comes he will learn to observe and appreciate the many laws which necessarily exist to restrict and control such an institution, but which would be of little value were not the young trained to naturally think and do right.

Courtesy and politeness are often innate and should be so early developed that no thought of disrespect to elders could enter his mind, and this principle should apply not only to those who are older but to his associates, every member of the household, and especially to the stranger and those in trouble.

Self-reliance should be a great asset, so that he may perfect the many faculties which lie latent in his nature.

The spirit of unselfishness if properly presented to the yearning young mind will develop and strengthen the attributes of true service, honesty, open-hearted preference, genuineness and other real virtues that go to form a strong and noble character. It may lead him to be active in civic betterment, in the enlargement of community privileges and in the upholding of the rights of the home, giving him an ideal of the best for his country.

Manliness in its generic sense must be taught early in life, that this particular quality of morality may lend its strong influence in assisting to develop the many other attributes which necessarily combine to make a true, well-rounded person.

Purity of language, whether at home, in school, or among associates, is an essential element to character-building. The abhorrence of the smutty, vile, coarse or indecent word should be instilled in the youthful mind, and especial emphasis laid upon the careless or thoughtless spoken word that so often mars the moral or cultured life of the user. The youth should be taught to finely discriminate between pure and impure words, coarse and refined expressions, passionate and impassionate thoughts, harsh and kind words, ugly and beautiful

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terms, necessary and unnecessary criticism, and as he advances into the years of self-government, the proper use of synonyms, which form such a large part of the English language. He should also be impressed with the importance of correct speech, which makes the young person a great asset to any social or cultured community.

The results of negation must be presented to his mind as over against those obtained by activity in all those qualifications which go to produce the highest type of citizenship. The lessons drawn from examples of bad habits are invaluable when properly and tactfully presented. In this connection the evil influence of bad or immoral companions should also be so thoroughly impressed upon his mind that he will avoid such associates as he would any influence which would take his life.

PART II.

For Youths in Their Teens.

With reference to the youth of high school age, one of the most fundamental ideas of morality, and one upon which so many others depend, is the respect for property of others, whether private or public. If he can be taught to respect that which does not belong to him in the same way as he cares for his own, he will be a protector of public property, a conservator of matter and wealth, and a person who will abhor and use his influence against the tendency toward theft and graft when he becomes fully developed. Naturally will follow that patriotism which brings honor to his country and to whose principles and development he will be loyal and true.

He should be taught that any services that he may render in the home and in his own community, whether they be little or great, will not necessarily be fully compensated for in a cash stipend, but what is far greater, they will bring love and honor to the home, the school, or the community in which he lives.

A high type of morality can best be secured from a healthy and strong body; therefore, the necessity of caring for one's physical health should be an important and unneglected part of the daily routine work. If athletic, the youth should show such a keen fondness and proficiency for the sports engaged in that his play will be vigorous, on the square, and with the purpose that the best one will always win. Thus he can easily see for himself the wisdom of keeping himself absolutely unfettered from all kinds of evil and destructive vices which destroy mind and body. In being taught to disrespect vice in

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all of its heinous ramifications he will understand that such indulgences lower his moral standard and hinder the development of a profitable and true citizen. Too much stress cannot be laid on the detrimental influence of bad habits, especially those which weaken the body or which, if exposed, cause reproach and shame.

He should be taught to be a worker and not a shirker, to work for what there is in his task and with the unison of faculties that will produce a high degree of efficiency.

Then should follow the virtue of being constructive, not destructive in his undertakings, bringing the ideas of morality into definite and complete operation, so that his labors can have no other result than that which will make his life worth while to live and his citizenship one to be honored.

A principle which some may depreciate, but which should be classed as a cardinal virtue, is promptness. He should always be in his proper place, on time, and ready for any work which he is asked to do.

The idea that any success in life will come through an active working mind can only be verified by the boy who, relying largely upon his own energies for the accomplishment of any task, has complete faith and trust in himself, and he will learn that to rely upon his own powers proves his own worth. He also discovers that to develop his various faculties he must so bring them into correlation with each other that he can command his whole being, instead of part of it, to accomplish his real purpose in life and to develop to a high degree his own worth.

He should be taught to avoid the foolishness of controversy and to apply the energies, which might here be wasted, to things of a constructive nature which will lead him to see the vital importance of seeking to increase his own productive powers in the vocation he wishes to pursue. Then naturally follows the importance of learning how to study oneself so as to discover the weaker points of one's nature, and how to strengthen and develop them into such attributes as will help one attain the highest type of manhood and womanhood. The will should be under complete control, but under no circumstances should any efforts be made to break or destroy the will of a youth, but influence should be brought to bear in such a way as to cause him to govern himself and thus develop the will to its very highest degree of individual action.

The social side of life has its demands. Sociability should

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be presented as an essential or cardinal characteristic, and if the young person is diffident, methods of development must be used in a subconscious way so that eventually this condition, which strongly hinders advancement, will be removed.

The youth should become a good humanizer, that is, a mingler or a mixer with people, being taught that a gracious appearance and an affable disposition help to make a personality which attracts rather than repels.

The moral status of the schools with which he connects himself, while in the main depending on other influences, at the same time is largely dependent on the moral standard of the students. Therefore, any youth, being a part of that school and desiring to secure the greatest amount of cultural instruction, must carry to it a type of morality similar to that which he would wish to perfect in his own character. He should be impressed with the thought that he exerts an influence and that he alone can decide its type, whether detrimental or a source of moral strength to those with whom he comes in contact.

A phase of high morality should be developed in his education as far as knowledge of the business world is concerned. The youth in his upper teens should have an understanding of civic affairs, of making an ideal home, and of the nature and form of his government developed to such a degree that he will take an interest in and do that which will raise the standard of civic righteousness to an ideal of his own creation. He should work for humanity for humanity's sake. In whatever line of activity he may be engaged, he should be impressed with the fact that he must be temperate in all things, especially fighting the evil of overdoing.

The youth should be instructed in the principle that he is a part of the family, and therefore should become a family helper to assist in retaining or raising its moral standard. He should be made to feel that the family is a unit, each member thereof being a partner with explicit duties, thus creating the interest and enthusiasm necessary to make that particular family among those of the highest moral worth to that community. If his moral attributes have the proper trend, he might act as a family counselor, as he might bring to it information which possibly could be secured in no other way, and it would enable him through personal observation to better discriminate between right and wrong.

In all morality work he should be a helper and not a hinderer;

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a true friend to all schemes for betterment of society; a student of not only civic but of physical and educational questions; a leader in character reform by studying and applying the suggestions given in this paper; and thus become a tower of strength to his companions.

The fact that big ideals should always be in front is supremely important in order that all phases of one's education may be so coupled together as to work toward the goal of a great ambition. Success depends very largely upon the possession of a clear, keen, active mind, which is the result of the development and embodiment of the various virtues herein mentioned. The brave heart is an attribute of a clear mind; therefore, with these two strong forces, the clear brain and the brave heart, the courage of one's convictions and the unhesitating realization of personal responsibility can carry to completion the most difficult tasks.

An attribute of great value here is that of determination to win. Success is what the youth wishes, and with firmness of character, correlation of faculties, and the spirit of determination incorporated within his mind, heart, and soul, he will win.

The youth should be taught to live, grow, and develop in a natural way largely through self-culture and discipline; to strengthen his own resources by becoming a reader of good literature; to be a lover of good biography; to become acquainted with those persons in history who have accomplished great things, to honor their successes and to profit by their mistakes. He should also be inculcated with the idea that under all circumstances he should be a gentleman of the highest type in order to meet his perfect ideal, and from whatever angle he may look, the virtues, attributes, and principles herein described, with their various viewpoints, should be within his horizon, to be incorporated into his life and to make him that type of citizen of which his family, his town, and his country will be proud.

Fifty cents each will be paid for back numbers of Vol. II, No. 3, May, 1902.

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ON THE HISTORY OF "PLAYFAIR'S PARALLEL-POSTULATE."

By Florian Cajori,
University of California.

The cumbersome form of the parallel-postulate given in Euclid's *Elements* has been generally displaced in modern text-books by an equivalent postulate, often called "Playfair's Postulate": "Two straight lines which intersect one another cannot be both parallel to the same straight line." A different phrasing is the following: "Through a given point not more than one parallel can be drawn to a given straight line." Either form is much simpler than Euclid's statement: "If a straight line meet two straight lines so as to make the two interior angles on the same side of it taken together less than two right angles, these straight lines, being continually produced, shall at length meet on that side on which are the angles which are less than two right angles." Playfair himself laid no claim to the postulate as he gave it; in fact, he stated in the "Notes" to his edition of Euclid that it "has been assumed by others, particularly by Ludlam, in his very useful little tract entitled *Rudiments of Mathematics*," 1785. We presume that Playfair quoted Ludlam as the earliest claimant known to him.

In view of the popularity of this postulate, not only in elementary texts but also in advanced treatises on the foundations of geometry, it may be of interest to cite an author using it who antedates both Playfair and Ludlam. This author is Joseph Fenn, who published an edition of Euclid's *Elements* in 1769 at Dublin. This Euclid is part of the "*First Volume of the Instructions given in the Drawing School established by the Dublin-Society, persuant to their Resolution of the Fourth of February, 1768. . . . Under the Direction of* Joseph Fenn, *heretofore Professor of Philosophy in the University of Nants, Dublin*, MDCCLXIX."[1] The usual sources of biographical and historical information fail to mention either him or his books. He argues in his edition of Euclid that the postulate given by Euclid "is not simple enough" and proceeds to remedy matters by interpolating between the 28th and 29th propositions of the first book a lemma that, if a straight line meeting two straight lines makes the alternate interior angles unequal, those two straight lines meet. In proving this lemma he makes use of a principle which in the body of the proof is designated as "C. N." (common notion): "A straight line which cuts one of two parallels will necessarily cut the other, provided this cutting

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line is sufficiently produced." This is the same as the assumption of Ludlam and Playfair. This principle, says Fenn, "Euclid regards as self-evident"; Euclid makes use of it, Fenn says, in the 30th and 37th propositions of the first book, where a straight line cutting one of two or three parallel lines is made to cut all of them. As a matter of fact, Euclid rightfully regarded this property of parallel lines as constituting an immediate consequence of his own parallel-postulate.

[1]The frontispiece of this volume represents the Greek philosopher Aristippus (regarded as having been unfriendly to mathematical pursuits) as shipwrecked on the coast of the Rhodians. When he observes geometrical figures drawn upon the rocks, he cries to his companions in distress: "Let us be of good cheer, for I see traces of man," and thereby admits that mathematics stands for intelligence.

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ON THEORIES CONCERNING SOILS AS MEDIA FOR PLANT GROWTH.

By Chas. B. Lipman,
University of California, Berkeley.

(*Continued from November Issue.*)

These theories, together with the so-called laws of Liebig which I have just cited, were the cause of protracted controversies, some of which were not settled for a period of fifteen or twenty years. Indeed, one of the controversies (the nitrogen question) was not fully disposed of until 1885. The disputes in question were the result of experimental work in the field carried on by Lawes and later by Lawes and Gilbert in England, and beginning about the same time as the famous experiments of Boussignault in France. By actual results obtained on the analysis of the ash of certain plants and by the response of such plants to fertilizer ingredients, Lawes and Gilbert demonstrated that the composition of the ash of plants was no necessary index to the needs of plants for the mineral elements. They also showed that the air could not be depended upon to furnish sufficient nitrogen to plants when the soil was unequal to the task, reserving as incomprehensible the case of leguminous plants which usually proved to be exceptions to this rule. I wish that time and your patience permitted me to descant on the more detailed phases of those remarkable experiments of Lawes and Gilbert, wonderfully conceived, accurately planned, and scrupulously and ably executed, which served to answer and effectively dispose of Liebig's mineral theory and largely of his nitrogen theory; to tell of Liebig's patent fertilizer and the story and reason for its failure; and to describe the numerous investigations which these theories stimulated. It is impossible, however, to go into all these matters in the brief space of an hour. I must, therefore, content myself with what I have told you of Liebig's work and with the further comment that despite a number of errors which crept into Liebig's theories, the latter were essentially sound, and while they constituted very largely amplifications of de Saussure's theories and facts, they remain as great achievements from the point of view of scientific propaganda. The position in the annals of agricultural chemistry and in plant physiology occupied by Liebig, however, represents only a small part of the credit which is due him in the general field and particularly in the organic part of chemistry.

Before passing on to the progress of soil theory after 1860,

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by which date the controversies between Lawes and Gilbert and Liebig were largely settled, there must be noted an old theory in regard to the cause of soil infertility, which has been of the greatest potency, directly or indirectly, in some of the most recent developments in soil theory. I refer to a modification of a very old idea of the selective powers of plant roots introduced into more or less modern literature by the distinguished French plant physiologist, Decandolle, in 1840. According to this theory, the roots of plants excrete certain substances which on accumulation become toxic to the same variety of plant, but not necessarily to other varieties of plants. Hence, the theory goes on to account for the benefits of crop rotation. It is interesting that this view should have been revived for the first time contemporaneously with the appearance of Liebig's report to the British Association, and particularly that it should have been regarded favorably by Liebig as the latter's more or less detailed consideration of it indicates. I shall return to a consideration of the Decandolle theory later in connection with a recrudescence of it in a period close to our own.

Great progress was being made in the sixties and seventies of the last century in all branches of science and much of it had its important relation to and effect upon soil theory. The brilliant work of Pasteur was going on and was opening the way for the development of modern microbiology, which dates from the discovery, by Robert Koch in 1882, of the plate method of isolating bacteria. Pfeffer and De Vries independently made their celebrated contributions to science in 1877 on the subject of osmotic pressure with particular reference to absorption by plants, thus rendering clearer the mechanism of salt action in the medium of plant growth. Many other pieces of outstanding work of a lesser magnitude were being accomplished. But none contributed anything to modify materially the theory of plant nutrition which may be regarded as a composite of the views of de Saussure, Liebig, and Lawes and Gilbert, on which all of those investigators would have agreed. Nor did any of them shed any light on the puzzling question of the legumes in connection with the nitrogen nutrition of plants. A radical departure from established experimental procedure was again needed as in several periods of the history of soil theory before. It was soon forthcoming, however, with the development of general, and closely on the heels therefore, of soil bacteriology. As far back as 1862, Pasteur suggested that nitrification was probably a bacte-

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rial process. Up to then, and even for some time after that, it was regarded as a chemical reaction taking place without the inter vention of living organisms. In 1877, however, the year in which Pfeffer and De Vries made their important contributions to the subject of the osmotic character of the soil, Schloesing and Muntz, two French investigators, definitely demonstrated the process of nitrification to be of biological origin. They found that when sewage containing ammonia was poured very slowly through tubes of sand, the ammonia would come through unchanged for a period of twenty days, after which it would disappear partly or wholly and its place would be taken by nitrates. When chloroform was poured into the tubes, nitrates would soon cease to appear in the filtrate and again ammonia would be found. When the chloroform was allowed to evaporate and the sand reinfected with some fresh soil, nitrates would again be found in the filtrate in a few days. This demonstrated beyond a peradventure that nitrification was a process due to living agencies. It took thirteen years more, however, and the patient attention and sedulous industry of a number of leading chemists and physiologists, culminating in the isolation of the nitrifying bacteria by Winogradsky in 1890, to make clear the process by which nitrogen in soil organic matter is rendered into nitrates.

Even this splendid work on nitrification, including Winogradsky's classic contribution, however, would still have left unexplained the abnormal behavior of legumes in the experiments of Lawes and Gilbert. But the necessary explanation was made through the striking and epoch making discoveries of Hellriegel, and of Hellriegel and Wilfarth, made public in 1885, and soon confirmed by Lawes and Gilbert, and by many others. These investigators found that when planted in a sterile medium, legumes do not behave abnormally, but respond to soluble nitrogen like non-legumes, growth being more or less regularly increased with every increment of nitrate nitrogen. When, however, the medium was not sterile, they would at times behave like non-legumes and at times not. They found, further, that nodules containing large numbers of bacteria were always found on the roots of the plants behaving abnormally. They connected these various facts and decided that the bacteria in the nodules on the roots of legumes, by some mechanism, obtained access to the large store of nitrogen in the air, which was not available to non-legumes, or to non-infected legumes. The nodules had been known since 1687, and the bacterial bodies in them

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had been known and described for a number of years before, but had not been directly and definitely connected with nitrogen fixation. Frank had suspected the connection and published his suspicions, but later retracted the idea. The organism of the legume nodules was isolated about 1888 by Beijerinck and named B. radicicola.

The puzzling questions and erroneous theories regarding both the transformation of soil nitrogen and the fixation of atmospheric nitrogen and their relations with the growth of legumes and non-legumes were thus finally cleared up and disposed of in the decade between 1880 and 1890. Other important contributions to our knowledge of the more intimate nature of soils, and the process of nitrogen transformation and fixation and of many other soil biological processes, have been made since 1885, but none of them has, in my opinion, affected fundamentally our theories on plant nutrition and on soil fertility; except that in general, as will be commonly agreed, the knowledge of the soil organisms which we have gained since 1882 constitutes an indispensable link in the chain of ineluctable evidence which indicates that the flora and perhaps the fauna of the soil are directly or indirectly essential factors in the transformation of all elements of plant food in the soil into usable forms.

For purposes of giving the proper perspective and necessary introduction to the next period in the development of our subject, it is well to pause for a moment and consider the circumstances which have contributed to it and made it possible. The history of soil theory may be divided by an arbitrary method, which I have adopted, into three periods. The first period covers the large era from ancient times to the beginning of the eighteenth century, which was characterized by much speculation, by little experimentation, and by scarcely any progress in the object of attaining unto a knowledge of how the plant feeds and grows. The second period may be said to begin about the year 1700 and to end about 200 years later. In the first half of this period, the experimental idea was rapidly developing and the aim of thinkers and investigators was to determine what the requirements for plant growth are. In the second part of this period, speculation was rapidly giving place to theory tested by carefully devised experiments, beginning with de Saussure and culminating in the researches by Liebig and his followers, Lawes and Gilbert, Hilgard, King, Grandeau and many others. It was in this part of the second period that the object sought from the

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beginning was successfully attained. The requirements for plant growth were finally determined. The parts played by the air, by water, and by the soil in plant nutrition were made clear and accurately appraised. But it must be noted that the school of de Saussure-Liebig-Lawes and Gilbert was one in which fundamental knowledge only of the *requirements* for plant growth were sought and found. They taught us little or nothing regarding the soil as a medium of growth to the point to which such teaching could be employed in formulating an idea of the conditions which control the power of the soil to yield heavily or lightly. In other words, it appears that the investigators of the nineteenth century assumed that the most difficult problem in plant production was solved when we learned what the requirements for plant growth are and their sources. The application of these principles had not progressed far enough to indicate to all concerned that it was necessary to know much more about plants and their media of development—soils—before we could hope to control the yields of crops on a thoroughly scientific basis. The investigators of those days could not see that it mattered little *cacteris paribus* how much of certain essential elements to plant growth were present in the soil at one time in the life of the plant, if they were not there in sufficient quantity at another period of its existence. They assumed that the soil constituted a static system in which, in some simple manner, water, aided by acids from decomposing organic matter and from root transudations, dissolved the minerals of the soil and maintained them at a more or less constant concentration. They assumed that the addition of soluble fertilizer salts to soils meant entire solution of the former and hence availability in toto to plants. With all these assumptions and many others in mind, the subject of the more intimate nature of soil reactions was ignored, merely analytical chemistry was applied to soils to determine total amounts of materials present, fertilizers were applied by empirical procedures; and in general, the outstanding work of Way, of the developing school of physical chemistry, and of Van Bemmelen on colloids were not considered as of much direct importance to a study of the soil. In other words, soil study *per se* was neglected. But the last years of the nineteenth century began to hear an occasional voice of protest from some of the investigators who were thinking hard on the subject of the soul-wearying soil analyses in vogue and their almost entire meaninglessness, on the riotous empiricism of fertilizer practices,

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and on the possibility of learning something more about the chemistry of the soil itself.

This was the status of the subject at the beginning of what I have classified as the third period in the history of soil theory and science, about the year 1900. The man to whom, in my opinion, we owe most for the inauguration of this new era is Cameron, whose work in turn was made possible through the fact of his connection with Whitney at the Bureau of Soils. Whitney's radical ideas on the functions of fertilizers, on the need for studying the soil's physical condition, and on the cause of soil infertility, made him rebel against the established order as early as 1892. He announced in that year that fertilizers function chiefly in improving the physical conditions of the soil and that the proper supply of water to plants by means of maintaining the proper physical conditions in the soil was the chief problem in crop production. Later on, he revived and amplified Decandolle's idea of toxic root excreta as being the chief cause of infertility in soils and the reason for the benefits of crop rotation by which means he believed fertility could be maintained. In these ideas Whitney was supported by Cameron, as above indicated, and by Schreiner and many other investigators at the Bureau of Soils. Cameron led the work on the physical and inorganic chemistry of soils, and Schreiner that on the organic chemistry of soils.

The longer Whitney and his associates studied the problem during the decade from 1893 to 1902, the more firmly convinced did they become of the validity of their theories. They appear to have regarded their theories subjectively, however, and made them the chief burden of the now celebrated Bulletin No. 22 of the Bureau of Soils by Whitney and Cameron, which was published in 1903. Since then, many papers have been published by the Bureau of Soils dealing with toxic root excreta and with studies on the physical chemistry of the soil or soil solution. The theory on the toxic root excreta has been made more inclusive and postulates also the presence in the soil of toxic organic substances produced in the decomposition of organic matter there. While nothing conclusive of practical significance has resulted from the search for such organic toxins, it has been demonstrated in those investigations, which are still going on, that toxic organic compounds are found in soils. Many such substances have been isolated from soil organic matter and much light has been shed on the organic chemistry of the soil, which,

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until the investigations of Schreiner and his associates at the Bureau of Soils, had been scarcely changed from the crude ideas held by Detmer, Mulder and others from fifty to seventy-five years before. While, therefore, it still remains to be shown that crops on infertile soils are arrested in growth and depressed in yield by organic toxins, whether originating from root excreta or from the decomposition of soil organic matter by the soil flora, science owes a debt to Schreiner, Livingston, Whitney, and to many others working at the Bureau of Soils at one time or another, who have been directly or indirectly responsible for giving us a more intimate picture than we had ever had of the nature and complexity of the soil organic matter.

We must retrace our steps a little to return to the publications of Cameron, to whose ingenuity, clear and incisive thinking, and courage we owe, in my opinion, the development of our modern physico-chemical views of soils just as we owe largely to Schreiner the development of our modern ideas on the organic chemistry of the soil. As early as 1901, Cameron began the publication of papers which attempted to show the application of physico-chemical principles to soil reactions. He pointed out the fact that the soil is to be regarded as a physical-chemical system in which the various minerals and water form a solution of a certain composition and concentration when equilibrium is attained in the system. Since most minerals are only slightly soluble in water and since practically all soils contain the important rock and soil forming minerals, Cameron argued that when equilibrium is attained in any soil, other conditions being equal, the composition of its solution, as well as its concentration, must be very much the same as that in any other soil. He was so impressed with this idea that he proceeded to test it out by making a series of soil extracts with water after brief digestions of the soil with water. The differences which he obtained between the composition and concentration of different soil solutions were regarded by Cameron as being small and insignificant and he, therefore, concluded, as he stated in 1903 in Bulletin 22, in joint authorship with Whitney, that all soils contain extracts of the same general nature and concentration, the latter being great enough to supply everything needed for big crops; and that, therefore, infertility of soils was not caused by a lack of the mineral elements of plant food in soils; that fertilizers did not function to supply any deficiencies in that direction; that infertility in soils is caused by the accumulation of toxic organic compounds in soils; that

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crop rotation would overcome the latter difficulty; and that fertilizers function to neutralize the effects of the root and soil toxins and to improve the physical condition of the soil. Cameron developed these and minor arguments in bulletins of the Bureau of Soils and in a series of papers published in the *Journal of Physical Chemistry*, and brought them together in what is, in my opinion, his epoch-making little volume entitled the "Soil Solution," which appeared in 1911. The basic principles in Cameron's theory consisted in first considering the soil-water system as a dynamic one in which constant movement and change of the components obtains, and second, that regardless of the total quantities of the chemical elements present in soil, it is the amounts of them in the soil solution, or in the water films investing the soil particles, which is the nutrient medium of the plant proper, which constitutes the important and significant factor in soil composition. Considered in the light of brief study and the comparatively meager development of physical chemistry a decade ago, the essentials of Cameron's ideas were theoretically correct, but like all soils investigators who have preceded him did, and like all who may follow him are likely to do, he overlooked some of the very points which his novel method of attack should have rendered clear to him. The more secure basis attained by physical chemistry since and the more deliberate thought on the whole subject with Cameron's views as a basis makes it appear today that the soil system is a dynamic one; that all soil problems must be considered in that light and not in the light of the static system which has been largely assumed for it heretofore; that soil minerals in all soils when attaining equilibrium with the soil water may yield solutions of approximately similar composition and concentration. But, and this was overlooked by Cameron, that the attainment of equilibrium in soils is not a rapid and facile phenomenon, if it is ever accomplished; that the large variations in the partial carbon dioxide pressures in different soil systems, and the great disparity which characterizes activities of microorganisms in various soils, for obvious reasons, vary the nature of the solvent to so large a degree that when the systems do attain equilibrium, their solutions may differ markedly in composition and concentration; that fertilizers do exercise important effects on the physical properties of soils, and may exercise antitoxic effects to the root excreta and soil toxins, but that their principal function is probably to affect directly by addition and indirectly by changing the solvent properties and reactive powers

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of the soil solution, the latter's composition and concentration. Cameron, as a physical chemist, should have appreciated that fact, but didn't, probably partly because of the results of his analyses of soil extracts obtained by a rapid method of digestion, which precluded the possibility of attaining equilibrium in the system. He does not seem to have appreciated sufficiently, moreover, the importance of the small differences in concentration between the different soil extracts which he obtained nor of the effect of season, and hence of temperature and moisture, in accomplishing marked changes in the dynamic system of the soil. He did not realize, as we do now, that the power of different soils to supply anew nutrients which are removed from the soil by rapidly growing plants varies widely.

All of these points have been developed in the last six or eight years and still constitute vital subjects of investigation in their different bearings and relationships today. While, thus, physical chemistry, a better training of our investigators, and better facilities, have permitted us to make rapid progress in our views concerning soils as media for plant growth and to modify considerably many of Cameron's important teachings, the latter loom large in the annals of our science. They represent a fundamental contribution which necessitated a keen mind, clear thinking, unusual gifts as a chemist, and more than the usual modicum of courage to enable their proponent to escape from the moorings of conservatism, and facing alone the scientific world to break the shackles which had held in bondage the ideas of soils investigators for sixty years. In other words, it is Cameron's attitude rather than his experimental data which constitute his contribution. It does not detract from the credit which is due him to point out, as I have above, some of the serious errors into which he was led by his theories and his disputes. His position is, in my opinion, destined to be secure and eminent in the annals of scientific investigations.

The theories of Cameron and those of Whitney which have been directly or indirectly responsible for the investigations of the Bureau of Soils did not, as may well have been surmised, go unchallenged. It would be impossible in so short a time as is now at my disposal to review the record of the controversies which have raged between the Bureau of Soils on the one hand, and the soil chemists and agronomists of this and other countries on the other, during the last fifteen year period, and particularly during the first ten thereof. Such well-known soils investigators

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as King, Hilgard, and Hopkins, and such organizations as the Association of Official Agricultural Chemists, have been aligned against Cameron and Whitney, and opposed to their theories. Due to the progress which I have just briefly sketched for you, which has been accomplished by soil chemists during the last six or eight years, the protests of conservative men and organizations have nearly all been silenced, however, and the general attitude adopted by Cameron with the modifications described, are accepted in this country today. Soil analysis by the strong acid digestion method and by the fusion method have been discontinued very largely and most chemists realize that it does little service to farming interests, and certainly to science, in the great majority of cases to determine how much of the elements essential to plant growth are to be found in soils. We have learned that we must devise methods for determining the composition and concentration of our soil solutions, must study the phase phenomena in such solutions, must learn what factors regulate all these in the field, and to supply the means by which they may be kept in optimum relations for plant growth. We owe much of our ultra-modern ideas on the soil solution, on methods for obtaining and studying it, and on soils in general, to a rapidly growing body of workers who are enabling us to shape Cameron's theories to the pattern of a vast body of new and striking facts. At the risk of making invidious distinctions by mentioning some and not others, I feel constrained to mention the outstanding work in the last five years of Bouyoucos, Morgan, Jordan, Burd, Hoagland and Stewart, Gillespie, Sharp and a few others who are applying with great success a few simple fundamental principles of physical chemistry to the study of soils. We owe a debt, further, to the plant physiologists who have been profiting, like the others, from the application of physical chemistry to their work. The results which they have obtained and which we are applying to good advantage in soils work are largely due to the outstanding investigations of Osterhout, Livingston, Dixon and Atkins, Stiles and Jorgensen, Brenchley, Shantz and of many others who are following in their footsteps.

From the combined results of modern plant physiologists and soil chemists, we are beginning to accord more importance to the role of the concentration of the soil solution as a medium of plant growth. In my opinion, a proper understanding of the effects of differences in concentration of the soil solution as affecting plants will probably go a great way toward solving some of the

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most difficult problems in plant physiology with which we are confronted today. Particularly the problems involved in the so-called physiological diseases of plants would, it seems to me, be made easier by an understanding of the effect of the concentration of the nutrient medium on the diseased plants. For example, in such diseases as die-back and mottled leaf in citrus trees, it is not unlikely that we are dealing with concentrations of salts in the soil solution which are many times higher than those to which the roots of citrus trees are accustomed in their natural habitats, and hence derangement of the normal function of the leaves may result. This is particularly possible when, in addition to a high concentration of salts, a state of balance between the constituents of the solution obtains which is inimical to plants. This will serve as an illustration of the great possibilities which are in store for us in studies of the concentration and balance of the soil solution. The experimental data and observations which support such a theory cannot be reviewed here.

For the sake of completeness, another theory on the infertility of soils, which has been advanced in the last seven or eight years, should be mentioned. It is the one proposed by Bolley, to account for "flax-sick" and "grain-sick" soils. Bolley believes that such soils are rendered infertile through the accumulations, in large numbers, of parasitic fungi, introduced with poor seed, and self-propagating in the soil, which develop with the young plants and depress their growth. This theory has not received much serious attention, however, in spite of the fact that all agronomists and soil chemists seem to agree that the fungi in question may contribute to the depression in yields of those soils. With the fungi removed by the use of good seed, crop rotation, and tillage, the essential problem of maintaining the soil's power to produce still remains.

With the more intense study of the soil itself, which has characterized the last few years, there has gradually grown a more and more insistent demand for accurate methods in such study. One important basis for such demands should be referred to here, in view of its overwhelming significance for the future of all soil studies. I refer to the very marked variability which characterizes soil samples gathered in any field, no matter how apparently uniform, and no matter how close together the samples are taken. Only within the past several months, Frear has called attention to this great variability, and, independently and contemporaneously, one of my colleagues, Waynick, has

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actually made a statistical study of one such case, the results of which not only are in agreement with Frear's view, but, in addition, lend mathematical precision to it. Moreover, it provides a basis by which such variability may be determined and a way is made open for the correct appraisal of the significance or insignificance of differences in the results obtained in experimental work.

I have given you in brief, and I fear only in fragmentary form, a survey of the important theories in the history of soils studies. Had I appreciated the true difficulty of the task of discussing them in so brief a space, I should probably not have undertaken it, since I realize how inadequately I have been able, for lack of time, to discuss some very interesting and important points which are involved. I trust that I have succeeded, however, in picturing to you the epochal monuments left by the great figures in the procession of thinkers and workers on soils, from the time of Virgil until today; to interpret for you the successive steps by which they have progressed; to appraise for you the relative importance of the contributions as I view them; and to give you a general idea of the status of our theories today. Above all, I desire to emphasize the fact that now, more than ever before, are we sadly wanting in the best kind of human material for our investigators in soils. The great triumphs of the past have indeed explained much, but, like all investigations, they have served to indicate much more that must yet be known and much that holds in store as great reputations and as many splendid victories as any of the phases of our problems which have been solved. But the problems which remain are of an intricacy and a difficulty probably surpassing anything which we have been obliged to face heretofore. We therefore need men who are second to none in imaginative capacity, in sheer mental vigor, and in training in physics, mathematics, and physical chemistry. To such, I can promise problems of an innate beauty, complexity, and fascination which are not surpassed in any other branch of science. I am optimist enough to believe that, though they have been slow in coming to us, we shall gradually impress such men with the importance of the work and enlist them in a service of the greatest interest to science, and hence of the greatest importance to mankind.

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ATOMIC STRUCTURE.[1]

By R. R. Ramsey,
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Within the last twenty-five years there has been a radical change in our ideas of electricity and the structure of matter. The year 1896 is a memorable one in the history of physics. In the early months of 1896 Roentgen's discovery of the X-rays were heralded over the earth as a wonderful discovery enabling one to look through his pocketbook. In 1896 Henri Becquerel discovered the Becquerel rays. That is, that there is an invisible radiation given off from uranium that will darken a photographic plate, this discovery being the first in the science of radioactivity. In 1896 Zeeman discovered that when the source of light is placed in a magnetic field, the lines in the spectrum of the light are broadened and separated into two or more bands. This was an experimental verification of the electron theory of matter put forth by Lorentz a few years before, this theory being that atoms are made up of a number of electrons carrying negative charges of electricity rotating about a central body.

The word electron and a rough idea of an electron had been put forth in 1874 by Dr. Johnstone Stoney of Belfast. In 1879 Sir William Crooks had demonstrated his tubes and the fourth state of matter. Lorentz had given his theory a few years later. But it was not until after 1896 that the theory was looked upon as having much experimental foundation. Thus the electron theory of matter may be said to be based upon three fundamental experiments, X-rays, radioactivity and the Zeeman effect. From these and subsequent experiments we are forced to believe that electricity is made up of electronic charges. That a wire carrying a current becomes hot by the bumping, sliding or friction, if you wish to call it friction, of these electrons or carriers of negative charges which move in the opposite direction to that which the current is said to move.

Our idea of atomic structure is crude and has changed many times in the last twenty years. No doubt it will change many times in the future. Our model atom must explain all known phenomena, and must be changed or reconstructed to explain any new fact that is discovered experimentally.

We cannot hope to dissect an atom and analyze its various parts as we would a machine, an engine, say. We are groping in the dark. Suppose you never saw an engine, never had read

[1]Read before the Physics and Chemistry Section of the Indiana State Teachers Association, Indianapolis, November 1, 1917.

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a description of one and you knew of no one who knew any more of engines than you did. And suppose you were set to the task of making a model of an engine. Suppose there was an engine running in a power house which was surrounded by a high tight board fence, the gates of which were securely locked. Before attempting to make your model engine you would go up to the fence and walk around the fence several times, paying close attention to every noise that could be heard. Then you would go to your workshop and make a model engine. Perhaps the only semblance to the real engine would be that you would have a model that would puff.

So it is with our atom model. We cannot discern and never can hope to be able to discern an individual atom by means of any of our five senses. It is only by means of indirect methods that we can see through a pocketbook. We detect radioactive substances by an indirect, electrical method, the electroscope.

Perhaps our model is at the puff stage. Perhaps it has passed that stage. Whatever the stage may be, we have arrived there after twenty years of listening and by twenty years of persistent hammering and prying at certain knots, trying to enlarge the holes so as to get a faint glimpse of the mechanism on the other side of the barrier.

There have been many models and theories of atomic structure proposed. Those that have survived are those that explain the various phenomena that have been observed. There has been a continuous patching, discarding, and reconstruction during the past two decades. The best model is the model that will explain all phenomena in the simplest manner.

Let us call attention to some of the things that must be explained, or look at that which an atom will do. At some of the things we have been able to see through our knot-hole.

1st. The elements combine with each other in definite proportion depending upon the atomic weight and valency. An atom of a certain element combines with one, two, sometimes more atoms of other elements but always in the same proportion with the particular element in question. This shows that matter is divided into definite chunks or atoms.

2d. The laws of electrolysis. A definite quantity of electricity carries a definite mass of metal from one plate to the other in a plating bath. Or, each element has a definite electro-chemical equivalent, depending upon the atomic weight and valency. We see that electricity and matter are connected in a definite manner.

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3d. The periodic table. When the elements are arranged in a table according to their chemical properties beginning with the lightest, hydrogen, and the next heaviest, we find that they are arranged in a definite series through the various groups and recur again in series. Thus sodium and potassium, which are very much alike and fall in the same group, have seven elements between them when arranged according to weights. Each of these seven other elements belong, one each, to seven groups. These seven, together with the one to which sodium and potassium belong, make eight groups in which all the elements are placed.

4th. Light. All sources of light are matter of some form, solid, liquid, or gaseous. The spectrum of any light depends upon the source. The pitch of any tone depends upon the vibration frequency of the string, reed, or pipe from which it is produced. Thus a siren will tell you the number of vibrations per second which the fork or sounding body is making. In the same manner the D line in the spectrum of sodium will tell us the number of vibrations per second that the sodium atom or something in the atom is making.

5th. Zeeman effect: The Zeeman effect, where a line in the spectrum is doubled or tripled by subjecting the source of light to a magnetic field, as has been stated before, was the first experimental proof of Lorentz's theory of atomic structure. The fact that the double or triple lines in the Zeeman spectrum are circularly polarized shows that the source of light, something in the atom, is rotating and is retarded or accelerated by a magnetic field.

6th. Radioactivity. The science of radioactivity has advanced until today there is no doubt that radium is a disintegration product of uranium and that radium in turn is disintegrating and forming new elements. It is also known that during the time that an atom of radium is disintegrating it is throwing off bodies whose mass is comparable to the mass of atoms and is also throwing off bodies whose mass is one or two thousand times smaller than the atomic masses thrown off. It is known that the smaller bodies are negatively charged and that the larger bodies are positively charged, and that the numerical value of the charges are in the ratio of one to two, the positive charge being the larger. Our model atom must account for radioactivity.

7th. X-rays are due to cathode rays or electrons in motion

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impinging upon a material target, a platinum anti-cathode, say. During the past five years the X-rays have been shown to be waves of very high frequency in the ether, or we may call them light waves whose wave length is thousands of times shorter than the wave length of ordinary light. Thus the atom when struck with a cathode ray must vibrate, or something in the atom must vibrate, with a frequency thousands of times greater than the frequency of light.

8th. Ionization. When X-rays or the radiation from radium passes through a gas it becomes conducting. The gas in the neighborhood of a red-hot wire becomes conducting. The gas in this conducting state is said to be ionized. We have an electron knocked off of a molecule of gas leaving the molecule positively charged and a free electron negatively charged. This electron may become attached to another molecule, making a negative molecule. This shows that an atom is made up of, or is surrounded with, electrons. A spherical pin-cushion full of pins might serve as an illustration.

9th. Photo electric effect. We have the photo-electric effect when a plate of zinc loses its charge when illuminated with ultra-violet light, or when the atom absorbs energy from the light.

10th. There are the various thermo-electric effects, Piezo-electric effects, and luminescent effects, all of which must be explained when we have our perfect model atom.

Various theories and models have been proposed. Probably the best and most simple is the Rutherford model, in which it is assumed that we have a central positive nucleus with one or more electrons rotating about it—a solar system, say, the sun the positive nucleus and the planets, electrons, rotating about it, the angular velocity of the electrons on the outside being less than those on the inside. In short, the planets or electrons obey Kepler's laws. This at once explains the Zeeman effect, assuming that the source of light is the electron moving in its orbit, the frequency of the vibration being the frequency of the electron in its orbit or at least is proportional to its frequency. A magnetic field will increase or decrease the radius of the orbit and thus change the frequency of rotation and consequently the position of the line in the spectrum.

The periodic series can be explained on this model if we make use of the Mayer experiment of the floating needles, which I had hoped to demonstrate here today. It is a long tedious task to attempt to explain the periodic series without the experiment

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and I shall not attempt to do so. Suffice it to say that the needles will arrange themselves in certain geometrical figures which will recur in series as the needles are placed in the field.

The atomic weight of an element is proportional to the number of electrons rotating about the nucleus, although the mass of the atom is not due to the mass of the electrons, according to the latest idea of the atom. Thus since the mass of the electron is about one-thousandth of the mass of the hydrogen atom, we do not say, in the latest theories, that a hydrogen atom is a system of one thousand or more electrons. Indeed, Mosley, from certain work on the X-ray spectrum, concludes that the hydrogen atom is a positive nucleus with one electron rotating about it. The fact that the hydrogen spectrum has more than one line is due to the fact that one electron may rotate in different manners and periods at different times and in different atoms. Probably light is always accompanied or caused by ionization of the source; or, light is given off just before an electron is knocked out of an atom or just after the electron has returned to its positive nucleus.

When a swift moving electron, as in the cathode ray, strikes an atom of matter, we have a disturbance set up in our planetary system. This disturbance causes perturbations or vibratory motions of the electrons in their orbits which is the source of a wave disturbance known as the X-rays. The frequency of the vibration will depend upon the particular atom struck. Thus the characteristic X-rays from a platinum target is different from the X-rays from a rhodium target. The frequency is proportional to the atomic number (Mosley).

If by chance an electron were to be thrown off from our planetary system there would be a rearrangement or disturbance of the remaining electrons similar to that caused when an extra electron comes into the system and we have an explanation of gamma rays from radioactive substances caused by an explosion which throws off an electron or beta ray, gamma rays being the same as X-rays. If the atoms or molecules are violently agitated, as in the case of an atom in an incandescent gas or wire, we might expect that some atoms would bump together in such a way as to knock off some few electrons. We thus have an explanation of the ionization produced by flames and hot wires.

Certain electrons in certain atoms might be so situated or in such a condition that they could be disturbed by certain wave motions. This agitation could be so violent in the case of sym-

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pathetic vibration that a few electrons would be thrown away from the atom and we have the photo-electric effect.

In a radioactive substance, uranium say, we will have to change our planetary system somewhat. We must still have a central positive nucleus or sun. Now let us call the electrons moons or planetoids. A number of these, 75 or 100, are revolving about the central sun. With these there are a number of planets, at least eight, in the case of uranium. The mass of these planets are four times the mass of the hydrogen atom, or the mass is the same as the mass of the helium atom. Each of these planets has at least two moons or electrons revolving about them. These systems or atoms are relatively unstable. At irregular periods we have an explosion and one of these heavier bodies is thrown off. We then have a new atom with different chemical properties and atomic weight. The body or alpha particle which is thrown off becomes an atom of helium, having a positive nucleus with two electrons rotating about it, the atomic weight being four. Thus our uranium atom, whose atomic weight is 238 and atomic number is 92, becomes an atom of uranium X after the atom of uranium has expelled an atom of helium. The atomic weight of uranium X is $238-4 = 234$.

After three of the heavier planets have been thrown off from our uranium system, we have an atom of radium which consists of the positive nucleus and 75 or 100 electrons rotating about the nucleus and at least five of the heavier planets. The atomic weight of radium is $238-(3\times4) = 226$. After the atom of radium has thrown off the five remaining helium atoms, we have radio-lead, whose atomic weight is $226-(5\times4) = 206$. The atomic weight of lead associated with uranium has been found by Richards to have an atomic weight less than the atomic weight of ordinary lead. The atom of lead is the positive nucleus with the 75 or 100 electrons revolving about it. As far as is known, it is stable and does not change. The lighter atoms differ from that of the lead atom only by the mass of the positive nucleus, the number of electrons, and the arrangement of the electrons about the nucleus.

Nothing has been said about the structure of the positive nucleus. No satisfactory theory has been put forth. It is known that the electrons are charged negatively, and in order to hold them in the planetary system there must be a central body, and it is assumed to be positively charged. Whether it is made of the same stuff as the electrons or of something entirely different

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has not been determined. To me it is not unthinkable that it may be made up of electrons in some state of motion or configuration which renders the resultant effect of the bunch as if they were charged positively. As an illustration of what I mean, take two negative charges or bunches of electrons and they repel each other. Take two parallel wires with the current in the same direction and they attract each other. Stationary charges repel and moving charges attract each other. Why can not the nucleus be made up of electrons the configuration and the state of which causes them to act as if they were positively charged?

I have thus in a more or less vague way attempted to explain some of the leading phenomena known about the atom. The Mayer figures are a great help in forming a concrete idea of the structure of an atom. To those interested in atomic structure the time used in setting up and in study of the Mayer experiment and the extension which I have proposed will be time well spent. It is a visible illustration of what may take place in an atom. Whether this model based upon Rutherford's atom will explain all other physical and chemical facts can be determined only by the results to be obtained in the future.

COAL TAR DYES.

By Herman Wright.

Within the last forty years modern chemistry has furnished the dyer with many beautiful colors prepared from material extracted from the refuse tar produced by the distillation of bituminous coal in the manufacture of illuminating gas. These colors are generally produced in aqueous solution and precipitated therefrom in a powdered or crystalline state by the addition of sodium chloride, common salt. When filtered out, washed and dried, they are ready for market. The coal tar colors are usually soluble in water. They possess a natural affinity for animal fibres, and the shades produced upon silk and wool are particularly brilliant. The coal tar dyes, however, are not classified according to their tinctorial power or the shades which they produce.

History.

Down to the middle of the nineteenth century, natural dyestuffs alone, with but few exceptions, were at the command of the dyer. But as early as the year 1834 the German chemist

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Range noticed that one of the products obtained by distilling coal tar, namely, aniline, gave a bright blue coloration under the influence of bleaching powder. No useful coloring matter, however, was obtained from this product, and it was reserved for the English chemist, Sir W. H. Perkins, to prepare the first aniline dye, namely, the purple coloring matter, mauve, in 1856. The discovery of other brilliant aniline dyestuffs followed in rapid succession, and the dyer was, in the course of a few years, furnished with magenta, aniline blue, Hoffman's violet, iodine green, Bismarck brown, aniline black, etc. Investigation has shown that the products of distillation of coal tar are very numerous, and some of them are found to be specially suitable for the preparation of coloring matter. Such, for example, are benzine, napthaline, and anthracene, from each of which distinct series of coloring matters are derived. In 1869 the German chemists, Goaebe and Libermann, succeeded in preparing alizarin, the coloring matter of the madder root, from the coal tar product anthracene, a discovery which is the greatest of all in historical interest since it is the first instance of the artificial production of a vegetable dyestuff. Another notable discovery is that of artificial indigo by Baeger in 1878. Since 1856, indeed, an ever increasing number of chemists has been busily engaged in pursuing scientific investigation with the view of preparing new coloring matters of coal tar products, and of these, a few typical colors with the dates of their discovery may be mentioned: Cachon de Laval (1873); Eosin (1874); Alizarin Blue (1877); Xylidine Scarlet (1878); Biebrich Scarlet (1879); Congo Red (1884); Premuline Red (1887); Rhodamine (1887); Paranitraniline Red (1889); Alizarin Bordeaux (1890); Alizarin Green (1895). At the present time it may truly be said that the dyer is furnished with quite an embarrassing number of coal tar dyestuffs which are capable of producing every variety of color, possessing the most diverse properties. Many of the colors are fugitive but a considerable number are permanent and withstand various influences, so that the general result for some years has been the gradual displacement of the older natural dyestuffs by the newer coal tar colors.

As most of you know, the supply of dyestuffs has for the most part come from Germany for the last forty years. All users of dyestuffs know this and they also know that there have been various attempts made in this country to produce the coal tar dyes. At this time there is invested in the coal tar products

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industry in Germany something like $400,000,000, probably more, employing some 50,000 people. Some of the factories pay dividends of 25 to 30 per cent after charging off a third of their profits to sinking funds for the erection of new plants and for other such purposes. This latter has been done for so long a period that most of the present property and plants do not appear on the books at all as assets, but have been built from the surplus profits. This is perhaps one reason why Germany has been so successful in the manufacture of dyestuffs. She has invested enormous sums of money, and as a result she manufactures these dyes on so large a scale that she can sell them at a very low price. Another reason for Germany's monopoly of the color-chemistry industry is the fact that there is a unity and solidarity of the various firms engaged in this industry, so that when one is menaced by any foreign competitor, they all act in unison. In America the field has been entered by many separated interests imperfectly acquainted with the complexity of the color problem, and a higher degree of unity is necessary in order to avoid overlapping and duplication of effort. Again, a reason why the United States has not been able to manufacture dyes is because Germans have discovered these dyes and have patented their manufacturing process, both in their own country and in the United States. The patents, however, are just now beginning to expire and the preeminence of German manufactured dyestuffs will soon be at an end.

The American people are just waking up to the fact that we are not doing for ourselves what we are able to do. It seems as though in the past there has been a tendency for the American people to let things of this nature be taken up and advanced by others. As long as the nations remained at peace with each other the United States succeeded in having their dyes produced in Germany without going to the trouble of manufacturing them themselves. Since the war, however, we have come to the realization that we must "help ourselves," as it were, and not depend upon other nations for the things which we can manufacture ourselves. One result of the war, according to an English authority, will be to put the United States on a footing of independence with regard to dye production, so that we will not only make all our own dyes, but export to foreign countries. The English writer in "Nature" (London, Dec. 16) warns his countrymen that when thus *forced* into new fields we may prove formidable competitors in the world's dye market. Before the war,

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he tells his readers, American dye-factories employed not more than 400 workmen and produced annually 3,000 tons of dyes, prepared chiefly from intermediate coal tar products made in Germany. Since that time new plants have been built, and the output of American coal tar colors will soon be trebled, while the production of benzine and toluene has increased fivefold.

So you see according to this we have not been altogether idle and we can do a thing and do it well after it has started, but owing to the extreme manufacture of explosives it is difficult at present to secure large quantities of these hydrocarbons for color production. Nevertheless, twelve firms have embarked on the manufacture of aniline; the Edison Company is now turning out three tons of this intermediate product daily. A remarkable and novel development has arisen in this branch of color industry. The firms engaged in dyeing aniline black are setting up small aniline plants, costing $1,500 to $2,000 each, capable, under the supervision of one operator, of producing daily 100 pounds of aniline from benzine.

Now if these various firms owning the small plants, were to cooperate with each other and with any other companies which might develop later, the United States would be producing dyes on much the same principle as is Germany and, in time, on much the same scale. At present, however, the seven companies engaged on finished coal tar dyes are restricting drastically the number of colors produced and are concentrating on increased output. Although the existing equipment for natural dyes installed in six large American works has proved to be a *national* asset of great value, yet the total supply of dyes is still far short of customary requirements, and the American public is urged to meet the abnormal situation in a spirit of generous compromise. The existing shortage will soon disappear, inasmuch as the United States possesses all the enterprise, inventive talent, and technical ability requisite for the development of an American dye industry.

Perhaps some skeptical person will now come forward and inquire as to the use of these coal tar dyes. True, we dye clothes and most textile fabrics and we have come to regard dyestuffs and their colors as highly important factors in the production of fabrics, nevertheless, if we approach the subject from the utilitarian point of view, we find that dyestuffs do not add any real quality to the fabric; the color of the cloth may add much to its artistic appearance and give it beauty and charm that appeal to

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our esthetic taste, but it cannot be said that color increases the durability, the strength, or the wearing qualities of the fabric. Outside of a certain influence upon heat and light rays, it is doubtful if color has any real influence upon the material value of the fabric. Our clothes would be of the same practical value to us if they were undyed as if they were dyed, they would wear just as well, in fact better, if they were never ornamented by the dyer's art.

Wherein, then, is the value of dyestuffs to the textile industry. To answer this: in the first place to satisfy man's natural love for ornamentation. Even the savage, wild as he is, decorates his scanty clothing with the varied, though limited, colors at his command. He is cultivating the love of beauty and any new color has a special attraction for him. It is this innate desire to decorate oneself and the things which one possesses and uses that has led to the widespread and almost universal application of dyestuffs in the manufacture of textile fabrics. In the second place, wholly aside from the artistic value is the desire to avoid, or rather to cover up, several undesirable features. When we wear our clothes for any length of time they become soiled. If the fabrics we use are white or undyed, their soiled condition is made apparent in a disagreeable manner. Consequently, we dye them in suitable colors, and though they still retain the same objectionable impurities, they are not so noticeable and we ignore them. Such of our clothing and other necessary articles, collars, undergarments, bed linen or table linen, towels, etc., as are left undyed are whitened thoroughly by bleaching, in order that when they become soiled they may present a disagreeable appearance and force us to take proper steps in cleansing them. Have you ever stopped to think why Italians prefer red bandana handkerchiefs, and why khaki colored shirts are so popular with camping parties? Think about it and you will find sufficient reason why dyes are important to the textile industry.

Now, why are coal tar dyes in more demand than the vegetable dyes which, it seems, are easier to produce? Or why have the synthetic dyes replaced the vegetable coloring matters? It is simply for the reason that the synthetic dyes could be produced cheaper and could be applied more simply and conveniently. Also, because more of the vegetable dyes were of an inferior quality as compared with the coal tar products. In the first place, the vegetable dyes were far from pure coloring matters. They consist principally of wood extracts and contained.

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besides the coloring matters, many other extractive substances such as tannins, sugars, resins, etc. It was a very costly proceeding to isolate pure coloring matter from these complex vegetable extracts, in fact, in most cases it was commercially impossible. On this account, the colors given by most vegetable dyes were more or less impure and not clear in tone. In the second place, there are only a few of the vegetable dyes which may be classed as really fast colors in the modern sense of the term. Indigo was no doubt the fastest color, and still represents the standard for comparison. Logwood, which was once universally employed for the dyeing of black on all classes of fabrics, could be employed for the dyeing of colors fast to washing, but not especially fast to light and exposure to weather.

Now with the synthetic dyes, although some are not fast or substantial, the majority of colors used are far better than even the cochineal, which was considered one of the best of the natural dyes. These coal tar dyes can be produced in the pure state and are not marketable unless pure, so the color produced by them is always distinctive and clear of tone. This, besides the cheapness with which the dyes can be manufactured in comparison with the production of vegetable dyes, accounts for the preeminence of the synthetic coloring matters.

Now that the German monopoly of the coal tar dyes has been shown, our present lack of factories, caused by various different reasons, and the present situation in regard to the United States and synthetic dyes, I will try to picture to some extent what the future has in store for the chemist in regard to the manufacture of coal tar dyes. In the first place, it takes a man with a great deal of chemical knowledge to manufacture these dyes, and it therefore opens up a field for these highly educated men and gives them an opportunity to develop for the world a very useful industry, and for themselves a reputation that will be of long standing and uplifting. Outside of these facts, the development of the dye industry will offer employment to thousands of men and offer to thousands more the means of advancement and the means of obtaining riches. Why will it do this? Because the success of the whole textile industry depends upon the quality of dyes put in them. You need not be told how large the textile industry is, and when you consider how closely the two are connected and the present scarcity of dyes, you will see the future of coal tar dyes.

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DOING OUR BIT IN THE TEACHING OF GEOMETRY.

By C. A. Hart,
Co-author Hart and Feltman's Geometry.

There never was a wider field for patriotic service than there is at present, and every earnest teacher who realizes the true meaning of the awful conflict in which we are now engaged, appreciating fully the issues which are at stake, must feel inspired to teach as he never taught before. For in conscientious teaching there is an almost infinite potentiality to counteract the propaganda which has been a menace to the solidarity of the United States, working its way insidiously into much of our school doctrine, promulgating a system which has for its goal a mechanical and soulless "efficiency" instead of the development of character in the search for truth, with the preservation and encouragement of individuality.

Nowhere perhaps is this breaking down of ideals more evident than in the mechanical teaching of mathematics which has gradually come into practice, especially in schools where pupils are trained to pass certain examinations. Everything which is not required by the examiners is rigorously cut out, and the dry bones of fact remaining are gone over and over and over again until the pupil is thoroughly acquainted with every turn of their limited surface.

In the good old days of the early Wentworth books the pupil was forced at least to experience such exercise of the imagination as was requisite for the solution of unclassified originals, but now the very perfection of parts of our best textbooks makes smooth the path for mechanical backsliding on the part of teachers who fail to realize the possibilities of mathematics, and particularly of geometry, as a study perhaps more powerful than any other for the awakening, strengthening, and developing of the highest faculties of the student. It is no wonder that otherwise progressive schoolmen are found who doubt the value of mathematics as a study; it is no wonder that other subjects are allowed to supplant it. When narrowly conceived and mechanically taught it has indeed no peculiar merit, for almost any subject can be so taught as to produce the same mechanical efficiency, if skillfully presented for such an end.

If, then, we are not keeping mathematics in the curriculum for its educational value, let us make short work of it. For mere practical use, a very few easy rules will suffice, and even these will be soon forgotten and unproductive of any good effects if not applied at once.

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It is not the attainment of mere mechanical proficiency which should be the aim of the teacher who has the true education (and not merely the instruction) of his pupil at heart, although such proficiency should become a useful and necessary by-product. But his goal should be rather the development of that open and honest attitude of mind, of that capacity for the earnest and determined search after truth, irrespective of consequences, that have always characterized great mathematicians.

Such a goal is to be attained primarily not by insistence upon parrot-like limitation to a fixed routine involving cut and dried formulae alone, but by a patient and not too rapid cultivation of the imagination, so that its elasticity may enable it to spring to new discoveries; by the vigorous arousing of a passion for truth, so that glimpses offered by the imagination shall not be accepted until verified; by the strengthening and toughening of the faculties of reason, whereby the irresistible conclusions derived from patient investigation are finally accepted and established.

Let us consider the means by which such ideals may be attained in the teaching of plane geometry, and the difficulties which beset our path.

First in logical order are the definitions. In any subject the definitions should be clear, logical, and as simple as possible. The definitions in plane geometry are no exceptions to the rule. Indeed, no subject calls for greater exactness and skill, and although the student need not be required to learn many definitions given in geometry and he cannot be expected to formulate his own, yet it is essential that his fundamental concepts shall be as sure and as accurate as possible. Few textbooks are satisfactory in this respect; for instance, take the definition (?), "A straight line is the shortest line joining two points." What is meant by shortest line? A straight line can be compared with another straight line, but the length of a straight line cannot be compared with that of a curve or that of a broken line or any other kind of line. Such a definition leads to a wrong attitude of mind, which once attained will be difficult to change later.

Again, a popular definition of an angle is "the amount of opening," etc. How can the vertex and sides of an angle be considered parts of it, if the angle is "the amount of opening," etc.?

It is suggested in some textbooks that if a circle is divided into 360 equal parts and the ends of one of these parts joined to the center by straight lines, the angle formed at the center is one de-

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gree. Yet, after accepting this statement for months, the pupil is then confronted with the theorem: "If two arcs are equal they subtend equal angles at the center." How confusing to any thoughtful student! How destructive of faith in the logical development of the subject! How hopelessly muddling to the ordinary mind!

Certainly a teacher must seem at least erratic if he considers the definition of a degree convincing and not requiring proof, and yet later insists upon a proof of the theorem quoted above. What idea is supposed to be conveyed by the definition of a degree, if we are to be uncertain (until the later theorem) whether all degrees are equal.

It is evident that there is little logic in such a sequence as that referred to above. A needless confusion is the natural result, and the only reason that a teacher may not protest against it is that he forgets how absurd such a procedure seemed to him when first presented to him, or else he never thought about it at all.

We are told that a semicircle is an arc equal to half a circle. A semicircle is not then a segment. Yet in the corollaries following the inscribed angle theorem, angles inscribed in semicircles and angles inscribed in segments are compared and it is implied that a semicircle is a segment.

A definition of a figure should be such that it is possible to draw it by following the definition as a direction. For example, if we say that a rhombus is a rhomboid having two adjacent angles equal, we may proceed thus:

Draw any line, as AX. Draw AY making any convenient oblique angle with AX. Lay off a convenient segment on AX as AD and lay off AB on AY = AD. Through B and D draw parallels to AX and AY respectively. Let these lines meet at C. Then ABCD is the required rhombus.

1. ABCD is a parallelogram. Its opposite sides are parallel by construction.

2. ABCD is a rhomboid. It is a parallelogram having an oblique angle by construction.

3. ABCD is a rhombus. It is a rhomboid having two adjacent sides equal by construction.

Many texts, however, give the following: "A rhombus is a rhomboid whose sides are equal." Now if we try to draw this figure according to directions we shall be confronted by requirements that are impossible to fulfill by construction. First we must construct a parallelogram having all its angles oblique. Having chosen the first oblique angle, is the next to be taken at random? How can we construct a quadrilateral having four oblique angles? We can construct three oblique angles in draw-

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ing our quadrilateral, but the fourth is determined by the three already constructed. The student has no means of knowing (without proof) that the fourth angle will turn out to be oblique in spite of his volition pro or con.

Even if all four oblique angles could be constructed, as implied by the definition, the pupil is now confronted by the necessity of making the figure a parallelogram, i. e., he must somehow secure opposite parallel sides.

Let the student begin over again, this time constructing the opposite sides parallel. Then he must prove that the angles are all oblique. Now grant that in some providential manner a rhomboid has been secured. It remains to get all the sides of this rhomboid equal. How is this to be done without beginning all over again? And how could he possibly draw the last line of the figure so as to make it equal the other three?

Some may think that this criticism is over exact, that the figure under consideration may safely be assumed as possible to construct, and that the student will see no difficulty in this connection.

But it must be admitted that the definitions of parallelograms must precede the theorems concerning them. How inconsistent it is then to assume a knowledge of the relations of the parts of the figures and afterwards prove that these relations exist.

The fact that the student may not discover the looseness and inconsistency of the definition is precisely the reason why the utmost care must be used. If he could discover the flaws in a poor textbook, it would matter very little what text should fall into his hands. Unfortunately, even teachers often fail to give clear and concise expression to their ideas, clinging with absurd tenacity to definitions to which they are accustomed, supposing that certain statements must be full of light for the students because they have become ground in, as it were, to the subconsciousness of the teacher.

For the sake of argument, however, let us grant that we have been too critical, and that such fineness of thought goes over the heads of the young. Of the two definitions given above, which is the simpler? Which is the easier to construct? Which is easier (after construction) to prove as fulfilling the requirements of the definition? In the later construction work it is of great value to be able to prove clearly and logically the correctness of a construction and, as in the case cited, to be able to proceed in a scientific manner from general to particular properties, showing first

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that the figure is a parallelogram; secondly, that it is a rhomboid; and thirdly, that it is a rhombus; giving evidence at every step of a clear concept of the properties of the quadrilaterals named, and the ability to classify them.

I have touched upon only a few of the definitions in common use. There are many others equally deplorable which are widely used but betray themselves to him who thinks.

Not only should definitions be given with great care, but the theory following should be consistent with the definition adopted. For example, suppose we agree that "a unit of surface is a square whose side is a unit of length" and that "the area of a surface is the number of units of surface which a given surface contains." Some authors even guard against misunderstanding by adding that area implies a number and not a vague largeness. It is a very common inconsistency a little later to attempt to prove that "Two rectangles having equal altitudes are to each other as their bases" in the following manner:

Call the two rectangles R and S, respectively. Assuming the bases commensurable, a common unit of measure is laid off upon them in turn, perpendiculars are erected at the points of division forming rectangles. Suppose there are r rectangles in rectangle R, and s rectangles in rectangle S. We are then told that

$$\frac{\text{area R}}{\text{area S}} = \frac{r}{s}.$$

Now from the definitions preceding this proof we are led to understand that area R means the number of square units in R, and area S means the number of square units in S. What then does R/S mean? And why does it equal r/s? If R/S does not mean the ratio of the measure numbers of the two rectangles what then does it mean? We must use every precaution against vagueness in the notion of size. How can we apply our definition of area to the case in point? In the next theorem, as usually given, "Any two rectangles are to each other as the product of their bases and their altitudes," the meaning of R/S becomes still more obscure. Is area R a number of unit squares? In area S, is the same unit square assumed? Are we to understand that four lines, the two bases and the two altitudes, all have a common unit of measure? Since the two rectangles are any two, must we expect R/S to be a rational fraction? If we are supposed to know that "any two rectangles" means two rectangles whose bases have a common measure and that this

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measure is also a measure of each altitude, then would it not be simpler to lay off the measures and find the real number of unit squares in each rectangle? Remember that all this confusion of ideas has been met without even attempting the proof for the incommensurable case.

Last of all, a third theorem appears telling us how to get the mysterious area of a rectangle (any rectangle?) which was certainly presupposed in the two preceding theorems. The proof of the third theorem is based upon the first two, which assumed the measure numbers (areas) of the rectangles involved. A vicious circle indeed!

Even the dullest pupil balks at the third theorem, having swallowed the other two, and perhaps having rather gloated over the cancellation of that unnecessary auxiliary third rectangle!

Another definition which leads to inconsistencies is that of a circumference. Some say that the circumference is the length of the circle. Yet they said previously that the circle was a curve, and later they discuss the area of a circle, i. e., the area of a line. Now what is the length of a curve? How can a curve be measured? How can a curve be a multiple of a straight line? Yet the pupil is told that the circumference is about 3 1/7 times the diameter (or π times the diameter) and the diameter is a straight line.

Again some proofs give the pupil the impression that the perimeter of some inscribed polygon will become the circumference of the circle if the number of sides is repeatedly doubled.

It is a confused impression, and no explicit statement is given as to how to go about measuring a curve. The pupil has no idea where π comes from. It is unrelated to anything that he has proved.

Now the fundamental principles connected with length of circumference (and also with area of circle) are both simple and fascinating.

One can easily show that the perimeter of a square circumscribed about a circle is 4, referred to the diameter as a unit, and that the perimeter of the inscribed square is 2.828427.

By drawing circumscribed and inscribed octagons, polygons of sixteen sides, etc., the pupil can easily prove that the perimeter of the circumscribed polygon decreases while that of the inscribed polygon increases. If we wish to make the work as simple as possible, we can give the following table without computation or proof.

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No. of sides.	Perimeter of inscribed polygon in terms of diameter.	Perimeter of circumscribed in terms of diameter.
4	2.828427	4.000000
8	3.061467	3.313708
16	3.121445	3.182597
32	3.136548	3.151724
64	3.140331	3.144118
128	3.141277	3.142223

and so on up to the polygons of 4096 sides whose perimeters agree to five decimal places, each being 3.14159+.

The pupil watches with great interest the growing agreement of the figures and he is quite ready to accept the definition: The length of a circumference is the common limit which the successive perimeters of inscribed and circumscribed regular polygons approach as the number of sides is successively increased and each side approaches zero as a limit.

It is a great satisfaction to the pupil to see that if he uses 3.1415 he is using an exact value, correct to four places of decimals, that it has a real definite meaning, that by continuing the table we may obtain values correct to as many places of decimals as we please.

Above all things we must strive to give the pupil correct fundamental principles. We must set his face toward the goal of truth. We must develop in him courage rather than vanity, patience rather than conceit.

There is plenty of easy work for encouragement. It is well in addition to this to have a true measure of one's capacity and also of one's attainment.

FULLER'S EARTH IN 1917.

The production of fuller's earth in 1917, as shown by a report published by the United States Geological Survey, Department of the Interior, was 72,870 short tons, valued at the mine at $776,632 or $10.66 a ton. The increase over 1916 was 5,048 tons, or 7 per cent, and $69,681, or nearly 10 per cent. Since its beginning, in 1895, this industry has almost steadily increased until, in 1917, its output and the value and average price per ton of its product were the highest yet attained. The output in 1917 was nearly eleven times greater than in 1895, and the value was nearly nineteen times greater.

Fuller's earth is found in many states, but in 1917 it was mined and marketed in only six. Florida was the leading producer in 1917, having been credited with more than three-fourths of the total output and value. The other states, named in order of production, were Georgia, Texas, Massachusetts, Arkansas, and California. The Southern States produced 98 per cent of the domestic fuller's earth marketed in 1917. The imports of fuller's earth, 16,994 short tons, also increased in 1917, but they formed only 19 per cent of the consumption.

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MAKING ALGEBRA FEED THE ALLIES.

FRANK M. RICH,
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While opinions of teachers may differ widely on the proposition of bread and butter as a chief end in school mathematics, especially high school mathematics, it is comparatively easy to agree when we have set before us a definite project of undoubted educational value that also carries with it a liberal serving of bread and butter on the side. Hence, I do not anticipate much opposition to the idea that if students of first year algebra can be taught to help relatives and neighbors to feed their stock and fertilize their gardens more economically through the help of the students' regular classroom exercises, there is certainly every reason for promoting this kind of mathematics drill in preference to traditional book material that presumably benefits nobody but the student himself.

Mixing problems in feeds and fertilizers furnish an abundance of drill in simultaneous equations, graphed or otherwise. The results have a real value for anybody who keeps an animal or plants a plot of ground. Although mere calculations, of course, cannot take the place of a certain amount of knowledge as to what kinds of feeds agree best with each kind of stock, what fertilizers, for instance, leach through open soils and are wasted, which improve the texture of such soils, etc., these calculations are of decided value in testing the ingredients used in any particular case, and in suggesting variations of proportions, where needed, to secure greater economy of production. Our proposal is to have the class learn to solve problems like those given here, and at the same time collect local problems from the neighbors for class, group, or individual solution, and return answers in which somebody is vitally interested. In other words, we propose that algebra be made to help feed the allies and ourselves, and incidentally, perhaps, to help justify a subject that, for the most part, has had too little justification, except that of a hypothetical mental discipline. In passing let us say that this is but one of a hundred ways in which algebraic calculation can be motivated for the average individual, even the boy and the girl, when practical needs and not academic traditions are made supreme in the teacher's and textbook maker's art.

BALANCED RATIONS.

One of the great secrets of economy in feeding animals is to

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balance their rations, so that all the food elements, nitrogen (protein), carbohydrates (starch-sugar), and fats, are furnished in the right proportion. Otherwise stock will be starved for the least abundant ingredients, or else fed more of the others than nature requires, with consequent loss of valuable material and strain on the animal's system in throwing off waste.

To illustrate: A pig needs 27 lb. of skim milk alone to produce a pound of growth. It needs 5 lb. of grain alone to produce a pound of growth. But mix the two, and 5 lb. of grain and only 15 lbs. of milk will produce the 2 lb. of growth, a clear saving of nearly half the milk.

Nutritive Ratio.

Pure fat is 2 1/4 times as nourishing as pure carbohydrate. Either one, for the most part, can be substituted for the other in that ratio. Many tables, for this reason, multiply the amount of fat by 2 1/4, and combine with carbohydrates to simplify figures.

The ratio of protein to the remaining nutrients, thus combined, is called the nutritive ratio. Below are tables of nutritive ratios of common feeds, and the nutritive ratios needed by the various kinds of stock. From them it is possible to calculate the proportion in which the various feeds will need to be combined. The results, based on nutritive ratios, refer to the proportions of nutrients actually digestible, not to gross weight of foodstuffs, which will depend upon the percentage of the foodstuff actually digestible, and can afterward be found by a separate calculation. Mere calculations, of course, are not the only things that have to be considered in feeding. Practically, the stock raiser has to consider palatability, bulk, laxative effect and price as well as proportion of mixtures. Individual animals, as well as individual people, vary somewhat in their requirements. All this, however, does not destroy the value of these calculations for anybody who has stock to feed, and wishes to do it in the most productive manner.

Illustrative Problem.

What proportions of skim milk and corn are best for a 5 mos. pig of 100 lb. weight, if one has plenty of both?

Skim milk: 8.8% digestible; nutritive ratio ..... 1 : 2
Corn, 84.3% digestible; nutritive ratio ..... 1 : 9.7
Pig requires 3 lbs. digestible; nutritive ratio ..... 1 : 5

1. To find the proportion of digestible nutrients in each:
Let x = number of parts of digestible nutrients in milk.
y = number of parts of digestible nutrients in corn.
$x/3$ = number of parts of protein in milk;

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$2x/3$ = number of parts of non-protein in milk;
$y/10.7$ = number of parts of protein in corn;
$9.7y/10.7$ = number of parts of non-protein in corn.

2. To find the gross weights of these feeds required:
Total number of parts of digestible nutrients required: 462;
Total number of lb. of digestible nutrients required: 3.
Each part, therefore = 3/462 lb. Milk = $141 \times 3/462 = 423/462$ lb. digestible. Dividing by .088 = 10.4 (approx.) lb. milk, (ans.)
Corn = $321 \times 3/462 = 962/462$ lb. digestible. Dividing by .843 = 2.5 lb. (approx.) corn (ans.).

In practical work, rations are seldom so simple as this. In feeding cattle, sheep, and horses, it is necessary to feed a certain amount of roughage (hay, fodder, silage, rootcrops) and several different kinds of concentrates (grain, seed cakes, molasses, etc.). In constructing the ration, find how much roughage the animals will clean up. Compute the amount of digestible protein and non-protein in the roughage; subtract from the total requirements of the animal and then work out the proportions of the remaining feeds, by simultaneous equations, so that the whole will balance properly. Where more than two concentrates are used, the proportions of some of them, particularly those of similar nutritive ratio, will have to be set arbitrarily and averaged together in the equation.

Illustrative Problem.

A 9 months calf weighing 500 lb. receives 9 lb. corn silage a day. How much shelled corn and cottonseed meal are needed to make a balanced ration?

Growing cattle require 1.74 lb. digestible nutrient per cwt.
Nutritive ratio for cattle 6-12 mos., 1 : 6.
Corn silage is 13.8% or .138 digestible; nutritive ratio 1 : 14.3.
Corn (grain) is 84.3% or .843 digestible; nutritive ratio 1 : 9.7.
Cottonseed meal is 81.6% or .816 digestible; nutritive ratio 1 : 1.2.

Solution of roughage.
9 lb. silage $\times$.138 digestible = 1.242 lb. digestible.
1 part protein in silage + 14.3 non-protein = 15.3 parts in all
1.242/15.3 = .081 lb. protein in silage.
1.242 − .081 = 1.161 lb. non-protein in silage.

Solution of remainder of the ration.
1.74 lb. per cwt. $\times$ 5 cwt. (wt. of calf) = 8.70 lb. nutr. required
1 part protein + 6 non-protein = 7 parts in all
8.70 lb./7 = 1.24 lb. protein calf requires
8.70 lb. − 1.24 = 7.46 lb. non-protein calf requires
1.24 lb. prot. calf requires − .081 lb. in silage = 1.159 more req.
7.46 lb. non-prot. calf requires − 1.161 lb. in silage = 6.299 more req.

Let x = number of pounds of corn needed
y = number of pounds of cottonseed meal needed.
$.843x$ = no. lb. digestible of corn.
$.816y$ = no. lb. digestible of cottonseed meal
$.843x/10.7$ = no. lb. protein in corn
$.816y/2.2$ = no. lb. protein in cottonseed meal
$9.7(.843x/10.7)$ = no. lb. non-protein in corn
$1.2(.816y/2.2)$ = no. lb. non-protein in cottonseed meal

Equation:

$$.843x/10.7 + .816y/2.2 = 1.159 \text{ lb. protein}$$

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$9.7(.843x/10.7)+1.2(.816y/2.2) = 6.299$ lb. non-protein
Solving,
$x = 7.3$ (approx.) lb. corn,
$y = 1.57$ (approx.) lb. cottonseed meal.

PRACTICE PROBLEMS IN RATIONING.

1. Make a table showing the amounts of each of the following combinations for the following ages of pigs:

Age (mos.)	Weight	Corn and Linseed Meal		Corn and Wheat Middlings		Corn	Skim milk
2 to 3	50 lb.						
3 to 5	100 lb.						
5 to 6	125 lb.						
6 to 8	170 lb.						

2. If 1/2 the feed of a heavily worked farm horse of 1500 lb. is balanced (clover hay and oats), find the weight of corn and bran needed to complete the ration.

3. If a heavily worked horse of 1200 lb. receives 10 lb. timothy hay and 8 lb. oats, find the balance of corn and bran needed.

4. Test the rule: 1 lb. concentrate and 1 lb. roughage for each 100 lb. of horse when the ration of 1200 lb. animal is corn stover, corn and bran.

5. Same when the ration is timothy hay, bran, corn and 8 lb. dried brewers' grains for 1500 lb. horse.

6. An 8 mos. lamb weighing 75 lb. receives 9 lb. corn silage a day. How much shelled corn and cottonseed meal are needed to make a balanced ration?

7. A 60 lb. sheep of 7 mos. gets 1.2 lb. mixed hay (average figures for timothy and clover) and 1.2 lb. roots (average the figures for mangels, carrots, and turnips). How much corn and bran are needed?

8. How much shelled corn and peas for the above?

9. A 1000 lb. cow yielding 22 lb. of average milk receives 20 lb. mixed hay and 3 lb. oats. Construct a balanced ration of corn meal and linseed meal.

10. Same for 40 lb. roots, 15 lb. corn stalks, 3 lb. oats, and the remainder wheat bran and gluten feed.

11. Same for 25 lb. corn silage, 5 lb. clover hay, 2 lb. oats and the remainder corn and cottonseed meal.

12. Same for 4 lb. oats and the remainder corn meal and alfalfa hay.

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Kind of Feed	Per Cent Digestible	Nutritive Ratio
Roughage		
Fodder corn	13.5	1 : 12.5
Peas and oats fodder	9.4	1 : 4.2
Red clover	19.3	1 : 5.6
Alfalfa	17.7	1 : 3.5
Corn silage	13.8	1 : 14.3
Potatoes	17.4	1 : 18.3
Mangels	6.7	1 : 5.1
Sugar beets	11.5	1 : 9.4
Carrots	9.	1 : 10.3
Turnips	8.7	1 : 7.7
Timothy	49.3	1 : 16.6
Red clover hay	46.4	1 : 5.8
Alfalfa hay	53.3	1 : 3.8
Oat straw	41.6	1 : 33.6
Concentrates		
Corn (grain)	84.3	1 : 9.7
Wheat	83.2	1 : 7.2
Rye	79.9	1 : 7.1
Barley	77.9	1 : 7.9
Oats	66.	1 : 6.2
Peas	70.2	1 : 3.2
Corn and cob meal	70.9	1 : 15.1
Wheat bran	57.5	1 : 3.7
Wheat middlings	73.5	1 : 4.7
Rye bran	66.3	1 : 4.8
Brewers' grains, wet	16.4	1 : 3.2
Brewers' grains, dry	63.5	1 : 3
Linseed meal	77.8	1 : 1.7
Buffalo gluten feed	93.1	1 : 3
Chicago gluten feed	79.	1 : 1.5
Cottonseed meal	81.6	1 : 1.2
Skim milk	08.8	1 : 2
Buttermilk	10.4	1 : 1.7

Kind of Stock	Lb. Digestible material needed per 100 lb. live weight per day	Nutritive Ratio
Oxen at rest in stall	.90	1 : 11.9
Oxen moderately worked	1.20	1 : 7.5
Oxen heavily worked	1.67	1 : 6
Wool sheep, coarser breeds	1.20	1 : 9
Wool sheep, finer breeds	1.35	1 : 8
Horses, lightly worked	1.19	1 : 6.9
Horses, moderately worked	1.35	1 : 6.9
Horses, heavily worked	1.66	1 : 6.2
Milch cows yielding 11 lb. milk	1.23	1 : 6.7
Milch cows yielding 16.6 lb. milk	1.39	1 : 6
Milch cows yielding 22 lb. milk	1.66	1 : 5.7
Milch cows yielding 27.5 lb. milk	1.81	1 : 4.5
Fattening oxen	1.89	1 : 6
Fattening sheep	1.93	1 : 4.5
Fattening swine	2.80	1 : 6
Growing cattle, 2-3 mos. old	2.23	1 : 4.6
Growing cattle, 3-6 mos. old	1.90	1 : 4.9
Growing cattle, 6-12 mos. old	1.74	1 : 6
Growing sheep, 5-6 mos. old	2.06	1 : 5.4
Growing sheep, 6-8 mos. old	1.74	1 : 5.4
Growing sheep, 8-11 mos. old	1.46	1 : 6
Growing fat pigs, 2-3 mos. old	3.75	1 : 4
Growing fat pigs, 3-5 mos. old	3.00	1 : 5

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Growing fat pigs, 5-6 mos. old	2.80	1 : 5.5
Growing fat pigs, 6-8 mos. old	2.38	1 : 6

PROBLEMS IN FERTILIZERS.

Computation of food of plants, or fertilizing materials is similar in some respects to that of food for animals. Plants require, and fertilizers contain, three chief ingredients, nitrogen, phosphorus (phosphoric acid) and potassium (potash). While some soils may contain one or more of these elements in almost unlimited quantities, it is necessary in most cases to supply some or all of them by artificial means, either to build up soils naturally poor in these elements, or to maintain good ones at their original high state of production. The fertilizer requirements of a given soil are usually determined by a series of narrow test strips through the field, some treated with one element, some with another, and some with combinations of two or three. Where plants on the fertilized strip show no improvement over the unfertilized control, it is reasonable to assume that the natural supply of this ingredient is already sufficient. Enough of the other substances should be added each year at least to balance the amount removed by the crop.

The following tables, and similar data that can be found in agricultural books, reports, fertilizer analyses, etc., enable one to compute the amount and proportions of fertilizer ingredients needed for a given situation. In using these, a word of instruction may be necessary. The methods of stating some of the formulas, especially by some of the fertilizer manufacturers, is somewhat deceptive to the novice. Where equivalents are given, e. g., "nitrogen equivalent to ammonia," "phosphoric acid equivalent to bone phosphate," "potash, equivalent to sulphate of potash," etc., percentages must be reduced in the proportion indicated in our table of fertilizers. Phosphoric acid may be listed in the analysis as, (1) available (soluble), (2) reverted (citrate soluble) and (3) insoluble. The first is made from bone, phosphatic rock, etc., treated with acid so that the resulting phosphoric acid is soluble in water and therefore available for immediate absorption by the plant. The reverted has had similar treatment but by standing has lost its water solubility. The insoluble is raw rock, slag or bone, unavailable for plant food till released by the slow action of weather, decaying organic material in contact with the mineral and possibly root secretions of the living plants. The figures to be used, therefore, will depend upon whether quick results or permanent fertility is most important.

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Fertilizing fields is such coarse work that a high degree of accuracy in the computation is not possible. Figures taken from different sources will vary considerably, as the grounds upon which tests are made vary. This, however, does not destroy the usefulness of computation to supplement judgment and experience, and any estimate carefully made is sure to be of value.

Illustrative Problem.

What quantities of dried blood (13 per cent nitrogen) and bone meal (3 per cent nit. and 24 per cent phos.) are needed for an acre of cereal ground, strong in potash, but requiring nitrogen and phosphoric acid in the proportions: 12 : 24 lbs. respectively.

Let x = no. lb. dried blood. $.13x$ = lb. nit. in dr. bl.
y = no. lb. bone meal. $.03y$ = nit. and $.24y$ = phos. in b. m.
Equation: $.13x+.03y$ = 12 lb. nitrogen required.
$.24y$ = 24 lb. phos. acid required.
Solving: y = 100 lb. bone meal; x = 70 (approx.) lb. dried blood.

Another Illustrative Problem.

A poultryman has a supply of wood ashes and also a limited quantity of hen manure which comes from the pens mixed with an equal weight of leaves. How much dissolved bone will he need to buy, and how shall he mix his own materials to the best advantage as a complete fertilizer for an acre of beets?

From the tables:

Analysis of hen manure:	2.	: 2.	: 1. %
Analysis of leaves	.7	: .15	: .3
Average of mixture	1.35	: 1.08	: .65%
Expressed decimally:	.0135	: .0108	: .0065

Dissolved bone expressed decimally: .02 : .20 : 0
Wood ashes expressed decimally: 0 : .01 : .05
Required for an acre of beets: 20 lb. nit. : 25 lb. phos. : 35 lb. potash
Let m = number lb. mixed manure and leaves needed per acre
a = number lb. wood ashes needed per acre
b = number lb. dissolved bone needed per acre

$$\begin{aligned} .0135m+.02b &= 20 \text{ lb. nitrogen required} \\ .0108m+.20b+.01a &= 25 \text{ lb. phos. acid required} \\ .0065m+\quad .05a &= 35 \text{ lb. potash required} \end{aligned}$$

Solving,

$$.0475m+1.00b = 90$$

m = 1450 (approx.) lb. mixture per acre.
b = 21 (approx.) lb. dissolved bone needed per acre.
a = 511 (approx.) lb. wood ashes needed.

Practice Problems in Mixing Fertilizers.

1. Substitute nitrate of soda and steamed bone for dried blood and bone meal in the first illustrative problem.

2. Substitute corn for beets in the second illustrative problem.

3. Compute the proportions of wood ashes and hen manure

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for an acre of celery on peaty soil where nitrogen can be neglected.

4. A farmer has applied enough floats to his land to furnish a permanent supply of phosphate when released by the action of farmyard manure. What quantities of this manure supplemented with sulfate of potash are needed for raising onions?

5. A gardener has plowed 5,000 lb. farmyard manure under an acre of tomato land. How much dried ferns and wood ashes would complete the fertilization?

6. Work out a balanced fertilizer of acid bone and sulfate of ammonia for an acre of cabbage on clay land where potash can be omitted.

7. In what quantities would you apply marsh hay supplemented with soot and a 1 : 8 : 0 fertilizer for .01 acre patch of lettuce?

8. Work out a balanced fertilizer of fish guano and a mixture of equal weights of bone meal and superphosphate for an acre of turnips where potash can be neglected.

9. In what ratio would you mix acid bone and fish tankage to make a 2 : 8 : 0 complete fertilizer?

10. In what proportion can a man growing celery on land poor in potash afford to exchange barnyard manure for wood ashes?

POUNDS OF NITROGEN, PHOSPHORIC ACID AND POTASH PER ACRE.

(Minimum requirement. Double the figures for maximum.)

Cereals: barley, 12:20:25; buckwheat, 15:30:35; corn and sorghum, 10:35:30; oats and rye, 12:20:30; wheat, 12:20:12.

Garden crops: asparagus, 20:30:35; cabbage and cauliflower, 40:70:90; celery, 40:50:65; cucumbers, muskmelon, pumpkin, squash, watermelon, 30:50:65; egg plant, 40:50:90; lettuce, 40:50:75; onions, 45:55:80; radishes, 15:35:45; spinach, 15:55:40; tomatoes, 25:35:40.

Grasses: lawns, 20:25:30; meadows and millet, 15:30:35; pasture, 15:30:40.

Legumes: alfalfa and clover, 5:30:40; beans and peas, 5:30:35.

Orchards and small fruits: apples, pears and quinces, 8:30:50; blackberries, 15:30:40; cherries and plums, 10:35:45; currants and gooseberries, 10:25:40; grapes, 8:30:45; nursery stock, 10:25:30; peaches, 15:40:55; strawberries, 25:55:70.

Root crops: beets and turnips, 20:25:35; carrots, 15:35:40; horse radish, 15:25:35; parsnips, 20:55:50; potatoes, 30:40:65.

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PERCENTAGE OF NITROGEN, PHOSPHORIC ACID AND POTASH IN COMMON FERTILIZING MATERIALS.

(Analyses vary considerably. Figures given represent rather high grade material. Commercial fertilizers are required by law to state formulas on the package.)

Nitrogenous: dried blood, 13:0:0; nitrate of soda (sodium nitrate), 15:0:0; sulfate of ammonia (ammonium sulfate), 20:0:0. In analyses and guarantees: ammonia = .82 nitrogen.

Phosphatic: acid phosphate (superphosphate, dissolved stone, acid stone), 0:16:0; basic slag (Thomas slag, iron phosphate), 0:15:0; floats (raw rock, raw phosphate, calcium phosphate, phosphate of lime), 0:12:0; acid bone black (dissolved bone black), 0:15:0.

Combined nitrogenous and phosphatic: acid bone (dissolved bone), 2:20:0; bone meal (ground bone, bone dust), 3:24:0; fish scrap (fish guano, fish tankage), 8:7:0; ground tankage (slaughter house refuse, meat guano), 7:9:0; steamed bone (degelatinized bone), 2:26:0; manure cake (rape cake, castor cake), 4:4:0.

Potash: muriate of potash (potassium chlorid), 0:0:50; kainit, 0:0:12; sulfate of potash (potassium sulfate), 0:0:45.

Combined phosphatic and potash: Wood ashes, 0:1:5; dry ferns, 0:3/8:1.8.

Combined nitrogenous, phosphatic and potash: corn stalks, 1/2:1/3:1 2/3; guano (peruvian guano), 5:18:3; cottonseed cake (cottonseed cake), 7:2 1/2: 1 1/2; farmyard manure, 1/2: 1/2:1/2; hen manure, dry, 2:2:1; leaves, .7:.15:.3; marsh hay, .8:.5:2.7; sheep manure, 2:1 1/2:1 1/2; straw, oat, .7:.2:1.1; straw, pea, 1:.3:1; soot, 2:1:1/4; compound manures (artificial fertilizers, complete fertilizers) various formulas: 1:8:0; 2:8:0; 2:8:1; 2:8:2; 4:8:2; 4:9:5; 11:5:1; 6:10:0, etc.

PIG IRON OUTPUT VALUED AT MORE THAN A BILLION DOLLARS.

The quantity of pig iron, exclusive of ferro-alloys, shipped or used by the producers in 1917, according to reports to the United States Geological Survey, amounted to 38,612,546 gross tons, valued at $1,053,785,975, compared with 39,126,324 gross tons, valued at $663,478,118 in 1916, a decrease of 1.32 per cent in quantity and an increase of 59 per cent in value. The average price per ton at furnaces in 1917, as reported to the Survey, was $27.29, compared with $16.96 in 1916, an increase of 61 per cent. The production of pig iron, including ferro-alloys, was 38,647,397 gross tons in 1917, compared with 39,434,797 gross tons in 1916, a decrease of 4.5 per cent, according to figures published by the American Iron and Steel Institute, March 18, 1918.

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AGRICULTURE AS PRESENTED BY SOME OF THE STATE NORMAL SCHOOLS.

By Oren E. Frazee,

Biology Department, State Normal School, St. Cloud, Minn.

This summarized report is based upon information received from eighty state normal schools in response to a questionnaire addressed to one hundred three Presidents of such schools. State normal schools from each of the following geographical divisions of states were included in the mailing list:

North Atlantic	North Central	South Atlantic	South Central	Western
Me.	Ohio	Del.	Ky.	Mont.
N. Hamp.	Ind.	Md.	Tenn.	Wyo.
Vt.	Ill.	D. C.	Ala.	Colo.
Mass.	Mich.	Va.	Miss.	N. M.
R. I.	Wis.	W. Va.	La.	Ariz.
Conn.	Minn.	N. C.	Tex.	Utah
N. Y.	Ia.	S. C.	Ark.	Nev.
N. J.	Mo.	Ga.	Okla.	Idaho
Pa.	N. D.	Fla.		Wash.
	S. D.			Ore.
	Neb.			Cal.
	Kan.			

The eighty replies are believed to reflect the situation with respect to agricultural courses in the state normal schools of the country as covered by the questionnaire, since practically every state is included in the list of replies.

Questionnaire.

The department of biology of the St. Cloud Normal School desires as accurate a statement to the following questions as is possible to make in a limited space. We shall be glad to send a copy of the summary of replies to those who desire it:

1. In what courses is Agriculture required?
   Number of weeks required?
   In what year or years of the course?
2. What are the courses in Agriculture offered for six weeks or more?
3. What courses in other departments are prerequisites?
4. Check the types of schools in which your graduates are eligible to teach Agriculture.
   Rural Graded High School
5. Are graduates of other state schools offering Agriculture given preference by law in appointments to positions?
6. Do you believe that the Normal School should attempt to train teachers in both the art and the science of Agriculture?
7. What is the approximate value of your material equipment for Agriculture?
8. What coordination exists between your school and the community agriculturally?
9. Please make constructive suggestions concerning Agriculture in the Normal School:
   a. Its function.
   b. Relative rank.
   c. Probable trend.
   d. Desirable changes, etc.

In answer to "In what courses of the normal school is Agri-

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culture required?" the data show that twenty-two schools (27 per cent) require agriculture in all courses (six describe the required work as Agricultural Nature Study, or Gardening). An observation of interest is that only four of the twenty-two normal schools requiring agriculture in all their courses are east of the Mississippi River. The eighteen remaining schools which require agriculture in all courses are widely scattered over the South Central and Western division of states. No schools from the North Atlantic division report agriculture in all of their courses. There are only four schools in the North Central and South Atlantic divisions which indicate in the replies that agriculture is required in all courses. Agricultural Nature Study, or Gardening, is required in all courses by six normal schools, four of which are located in the North Atlantic division, the remaining two are located in the North Central division.

In support of the plan to require agricultural training for the preparation of all teachers by normal schools, an instructor in a middle western normal school writes: "Every teacher should know something of this greatest of American industries, and certainly teachers of the rural and graded schools, besides the teachers of the biological sciences in the high schools, should be thus prepared."

The president of a normal school in the extreme west says: "I think it probable that all of our science work in the normal school will ultimately be tied up with agriculture and household economics. I believe its importance will be recognized more and more until it will become one of the most vital subjects in the curriculum."

An additional point of interest is that these twenty-two western normal schools, reporting that agriculture is required in all their courses, also indicate that normal schools should train students both in the art and science of agriculture.

"If the teacher of agriculture is to be of any value to the high schools of the state, or even rural schools," said one writer, from the North Central division, "he must be trained in the art and science of agriculture by the normal school." Another of the North Central division said, "I regret that our normal schools have not felt free . . . to train teachers for any phase of public school work including agriculture." A president of a western normal wrote: "Rural, graded, and high school teachers of agriculture must come from the normal schools. Graduates from agricultural colleges are entirely taken up with

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other lines of work. With a little more equipment the normal schools can prepare teachers of agriculture better than the colleges." From very few was there corroboration of this view: "I firmly believe a normal school should stick to the job of preparing teachers for elementary school work. . . . I see no use trying to compete with and duplicate the plant of the state college." From the North Atlantic division, however, came a number of replies adverse to placing agriculture in the normal curriculum. These replies are epitomized by the following quotations: "It is foolish to teach agriculture (even as a science) in city schools. . . . We have more important things to do than teach appreciation of the farmer's service to the country. . . . One can form no adequate idea of the farm from a study of farm life in the city. I doubt the wisdom, even the possibility, of accomplishing much in the field so long as practically all of our students are young women."

Twenty-four schools (30 per cent) require agriculture in rural and graded school courses. The twenty-four schools requiring agriculture in the rural and graded school courses only are, with four exceptions, situated in the North Central division and in all cases, save two, their students are eligible to teach agriculture in the high schools. If we examine the total number of schools which may prepare teachers of agriculture for high school positions (see data on question 4) it is found that these thirty-eight schools are situated mainly in the North Central, South Central, and Western divisions. In some of these cases, however, it is stated that preference is given, though not necessarily through legal enactment, to the college trained teacher of agriculture. It works out in some instances after the situation in Illinois as stated by President W. P. Morgan of the Macomb State Normal. He says, "Graduates of other state schools are given preference to a degree, due to the fact that high schools to be accredited at the University must have a certain number of college graduates on their faculty."

Five schools (6 per cent) require agriculture in the regular course (possibly these should be included with the twenty-two above); three schools require it in agriculture and advanced courses only; two in science and household arts only; while it is reported as elective in two schools; and not required for any course in eighteen schools (22 per cent). One of these, however, makes it a requirement for admission. These eighteen schools are scattered over the entire country but more than 50 per cent

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of them are located in the North Atlantic division. The most frequent explanation offered by those not requiring agriculture for any course is that their students are largely from the cities, and when the student has received his training he returns to the city to teach, hence it is impracticable to include agriculture in the curriculum. Some of these offer, but do not require it in every case, work in school gardening especially adapted to the city, or the suburban districts.

In tabulating the replies received to the question "Number of weeks Agriculture is required?" it was found convenient to group the replies under 12, 18, 24, 36, 48, 72 or more weeks, notwithstanding that this necessitated some approximations, for example, "One year is required" is counted 36 weeks, and "nine weeks" or "twenty-seven weeks" are counted 12 weeks or 24 weeks respectively; and fractional parts of a year are reduced to weeks before tabulation. The data show that ten schools require agriculture for 12 weeks; eleven schools require it for 18 weeks; four schools require it for 24 weeks; twenty-four schools require it for 36 weeks (40 per cent); four schools require it for 48 weeks; and eight schools require it for 72 weeks or more. Of these eight schools, two schools require agriculture for four years, and one requires agriculture each term in its five-year course. A study of these answers in relation to the answers to number one above reveals, first, that there is no school requiring agriculture in all of its courses which does not devote at least thirty-six weeks to the subject, while many schools require it for two years; second, that those requiring less than thirty-six weeks, especially those giving but twelve weeks, are the normal schools which have agriculture in the rural courses. These courses are frequently not more than twelve weeks in length.

In answer to "In what year or years in the course is Agriculture required?" the tabulation includes some schools which do not require agriculture but offer it as an elective in certain years of the course. The data show that fifteen schools place it in the first year; fifteen in the second; nine in the third; fourteen in the fourth; one in the fifth; seven require it every year (this number includes some having but two years normal training); and in fifteen schools it is optional with the student which year he pursues it.

"What are the courses in Agriculture offered for six weeks or more?" Such a great variety of similar expressions was used in

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the replies to designate the same course that it seemed best to group those courses which are apparently alike. General agriculture (includes elementary agriculture) is taught for six weeks or more in forty-four schools (50 per cent); animal husbandry (includes farm animal courses) is taught in twenty schools; soils (includes courses in soil physics), eighteen schools; farm crops and cropping, thirteen schools, horticulture, thirteen schools; gardening, ten schools; agronomy, eight schools; dairy husbandry, seven schools; feeds and feeding, six schools; farm management, six schools; plant propagation (includes plant breeding), seven schools; poultry, four schools; stock judging, three schools; weeds, three schools; rural economics, three schools; farm mechanics, two schools; forestry, two schools; one school reports for each of the following subjects—methods in agriculture, economic entomology, bacteriology, plant pathology, agricultural chemistry. There is overlapping in these courses to some extent. For instance, in the case of the forty-four schools offering six weeks or more of general agriculture, a number of these offer certain special courses in the subject to follow the twenty-four or thirty-six weeks of general agriculture. Also, some schools differentiate their courses but frequently this may not cover any wider field than those schools which reported simply general agriculture. Differentiation of courses is prominent, however, in those schools of the South Central and Western divisions which require agriculture of all students. The following seems to be fairly typical of such differentiation. The school referred to requires agriculture of all students for one year. The subjects offered for six weeks or more are: a. General agriculture. b. Animal husbandry. c. Horticulture. d. Farm crops. e. Farm management. This makes it possible for students to secure a range in the selection of courses to suit their needs and still satisfy the time requirement.

"What courses in other departments are prerequisite to Agriculture?" There are forty-five normal schools (56 per cent) which admit students to the agricultural courses without any special prerequisite (six of these are schools which require agriculture in all courses); ten schools name biology as a prerequisite; seven schools require chemistry; seven schools require three to four years of high school work; botany is prerequisite in three schools; physics, in two schools; commercial branches, in two schools; physiography, in twelve schools; elementary agriculture, in two schools; zoology, in one school.

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"Check the types of schools in which your graduates are eligible to teach Agriculture—Rural; Graded; High School." The tabulation of replies shows that sixty-three normal schools (79 per cent) prepare teachers of Agriculture for rural schools, three of which prepare for rural schools alone; 60 normal schools (75 per cent) may prepare teachers of agriculture for graded schools as well as for rural schools; thirty-eight normal schools (48 per cent) may prepare teachers of agriculture for high schools in addition to the preparation of teachers for the elementary schools.

With respect to the preparation of teachers of agriculture for the high schools, there seems to be a definite movement to do so in the North Central, South Central and Western divisions. In many of the schools of these sections the replies indicate an extension of the curriculum to include more agricultural training of the teachers. Many replies indicate, with expressions such as "after 1918," or "soon," that certain changes would obtain in their schools, the effecting of which would materially strengthen their agricultural department. Replying to the questionnaire, Professor U. O. Cox of the Indiana State Normal School at Terre Haute gave the following comment concerning the extension of the courses in that institution: "Our courses now for graduation are all four years in length, with a degree for each course. There is the regular college course, A. B., the normal course, Ph. B., and the vocational courses, B. S. (Household Economics, Industrial Arts, and Agriculture). . . . At present we are not giving all of the agriculture course but hope to do so very soon. We expect to have a farm fully equipped in the near future. We have a new building with special laboratories which is nearly ready." Obviously, from this and from similar replies, the normal schools are planning to enter this field of work to help supply the insistent demand of schools for better trained teachers of agriculture.

"Are graduates of other state schools offering Agriculture given preference by law in appointments to positions?" The replies of forty-three normal schools (54 per cent) indicate that there is no such statutory regulation in their respective states; five schools indicate "Yes"; five indicate "If position is in high school"; three indicate "Possibly university graduates are given preference." A few were not informed concerning the existence or non-existence of such provision.

"Do you believe that the normal school should attempt to

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train teachers both in the art and the science of Agriculture?" The normal schools which responded to tnis are in substantial agreement that the normal school should do so. The replies indicate 70 per cent favoring while the remaining 30 per cent are about equally divided in opinion as follows: Ten schools indicate "No"; four schools in science only; two schools in art only; two schools, "Special schools (preferably normal schools) should be delegated to do the work in agriculture." While the number was large who believed that the training of teachers of agriculture by the normal schools should include training both in the art and science, many did not think the conditions were such that it could be effected at the present time. Some states, for example, have a number of normal schools, other states lack equipment, and some suggested that the best way out of the difficulty is to allow the technical schools to do all of this work. In this connection, the Wisconsin system of department specialization is favored in a number of the replies, all, however, from states similar to Wisconsin in that several normal schools serve the state.

The arrangement as described by President Cotton of the La Crosse Wisconsin Normal is: "Each normal school in the Wisconsin system has a specialized department. The schools at both River Falls and Platteville, Wisconsin, have the specialized department of agriculture. Graduates from these schools teach agriculture in the rural schools, state graded schools, and the high schools of the state." He added: "I believe that one or two normal schools in each state should attempt to train teachers both in the art and science of agriculture. I do not think it would be necessary to have all of the schools attempt so much when there are several normal schools in the state."

"What is the approximate value of your material equipment for Agriculture?" The data show that one normal school has an estimated material equipment of $100,000; five schools have approximately $50,000 each; seven have $10,000 each; eight with $5,000 each; nine have $1,000 each; fourteen have $500 each; six with $100 each; and five report, "Little or nominal."

"What coordination exists between your school and the community agriculturally?" Twenty-two schools (45 per cent) indicate that there is no coordination of the work of the school and the agriculture of the community; ten schools do club work, or cooperate with a county agent; nine schools do certain types of practical work, such as soil testing, determining species of

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insects, suggesting building plans, etc.; six schools do extension work, including lectures, and conduct experiments; one normal school does supervision work in the teaching of agriculture in district schools.

"Please make suggestive criticisms concerning Agriculture in the normal school; a. Its function; b. Relative rank; c. Probable trend; d. Desirable changes." The replies to (a) are practically unanimous in the belief that the function of agriculture in the normal school is to develop in the minds of young men and women a point of view with respect to the problems of rural communities. This would include a training which would emphasize, first, the art and science of agriculture; second, an appreciation and understanding of rural problems; and third, practical problems. The minority of those who answered this question was divided largely between those who would attach importance only to the practical aspects of the problem, and those who would emphasize the science of agriculture, or the art of agriculture, alone.

In reply to (b) and (c) the sentiment of the majority seems to be reflected in the thought that agriculture has a "relatively growing importance" in the normal curriculum. One reply indicated that it would be dependent upon the final interpretation given to the "Smith-Hughes Act." A few replies indicated that "Home Project Work" would soon be much more general than now.

In reply to (d) the sentiment, aside from those having in mind purely local matters of administration, is, first, that the subject needs to be vitalized in the curriculum; second, that it should be more generally required; third, that it should be taught in the training school.

The questionnaire has determined that agriculture as a fundamental part of the normal school curriculum is not only acceptable but also that it is very rapidly developing to meet the needs of the schools of the community.

Fifty cents each will be paid for back numbers of Vol. II, No. 3, May, 1902.

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SHUNT MOTOR.

By E. C. Mayer,
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Part I. Introduction.

A. Comparisons of Generators and Motors.

Dynamo electric machines are generally divided into two classes, generators and motors. A generator is a machine which is supplied with mechanical energy, which it transforms and delivers as electric energy in the form of an electric current; a motor is a machine which is supplied with electric energy, which is transformed into mechanical energy, and as such is available at the pulley end of the motor shaft. Structurally, the two machines are alike. Each consists, if attention is devoted to direct current machines only, of field magnets, which are large electromagnets suitably mounted on iron cores attached to the field frame, and a revolving armature, consisting of a cylindrical iron core on whose outer periphery are many conductors, so arranged as to cut the magnetic lines of force emanating from the field electromagnets. Direct current machines are also provided with a commutator[1], and at least two brushes, by means of which connection is made with the external circuits.

Faraday's laws of electromagnetic induction state that a conductor, moving in a magnetic field so as to cut lines of force, is the seat of an electromotive force. The existence of this E. M. F. depends only upon the relative motion of the magnetic field and the conductor. That is, an E. M. F. is likewise produced in a stationary conductor by moving a magnetic field past it. So that in practice one finds generators with stationary field magnets and revolving armature, or vice versa.

B. Relation Between Impressed Voltage, Counter E. M. F., Flux, Speed, Current and Torque.

By a consideration of Fig. 1, which represents diagrammatically one conductor A, of an armature revolving between the field magnets, N and S, of a generator, according to Fleming's right-hand rule,[2] there is an induced E. M. F. developed in A which gives rise to a current in A in a direction perpendicular to the plane of the paper and towards the observer. A current flowing towards the observer is usually represented, as in the figure,

[1] A brief description of a commutator, together with its operation, is given in a previous experiment on the shunt generator.

[2] See experiment on Shunt Generator, School Science and Mathematics, Vol. XVII, No. 2, 1917.

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by a dot (.); one flowing away from the observer is represented by (x). For simplicity, the diagram indicates the magnetic field as parallel rather than radical, as is usually the case in actual machines. Now the current which flows in A maintains its own individual magnetic field, which is a series of loops surrounding A, one of which is indicated in the figure. This magnetic field strengthens the field of the field magnets on one side of A (the lower side) and weakens and partially neutralizes it on the other side of A. Thus is seen why in a generator the field flux, due to the combined actions of all armature conductors, is crowded towards one pole tip (the trailing tip) of the field magnet. In a motor the action is reverse and the field flux is crowded towards the leading pole tip.

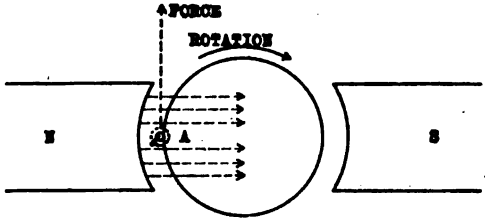

Figure 1

From the results of experiment, a conductor conveying a current and moving in a magnetic field so as to cut the lines of force experiences a mechanical retarding force, which is in the direction opposite to that of the motion. Thus, in Fig. 1 there is a force exerted upon the conductor A, vertically upward, which force produces a moment or torque which tends to oppose the rotation of the armature. And in order for it to revolve, the driving engine must be sufficiently able to turn the armature at the required rate in spite of the opposition due to the retarding torque. This may be considered a counter-torque. A rule known as Fleming's left-hand rule,[3] to give the direction of this mechanical force when the directions of external magnetic field and current are given, is as follows: Extend the thumb and first two fingers of the left hand so that they are mutually perpendicular. If the first finger is pointed in the direction of the field and the second or middle finger in the direction of the flow of current, the thumb will indicate the direction of mechanical force.

In the case of a motor, suppose a constant voltage is applied to the armature, such that current flows in A towards the observer as indicated in Fig. 2.

[3]Compare with Fleming's right-hand rule.

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According to the above rule, the mechanical force on A and the other armature conductors will produce a driving torque which will cause the armature to revolve clockwise in the magnetic

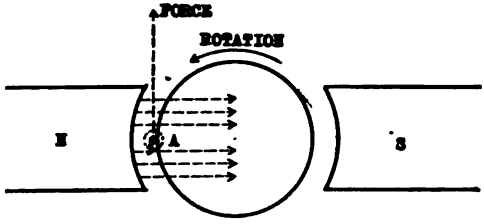

Figure 2

field between N and S. Now, since A is moving in a magnetic field, it will become the seat of an induced E. M. F., which, according to Fleming's right-hand rule, will be directed in A away from the observer and will therefore tend to oppose the original flow of current. In order to maintain the armature current, it will be necessary for the impressed voltage to be sufficient, not only to overcome the impedance offered by the armature winding, but also to overcome the induced E. M. F., which is technically known as a counter E. M. F. This may be expressed as follows:

(1) $E = E_c + R_A I_A$

where E is the constant[4] E. M. F. impressed at the brushes of the motor.

E_c[5] is the counter E. M. F.

R_A is the resistance of the armature circuit between the brushes.

I_A is the armature current.

The E. M. F., E_c, induced in the armature, has the same value as if the machine were functioning as a generator. It was shown[6] to be equal to $\phi NpZ \times 10^{-8}$ where ϕ is the flux emanating from one pole, N is revolutions per second (speed), p is number of poles, Z is total number of conductors in series between the two brushes, or

(2) $E_c = k\phi N$ where K is the constant $pZ \times 10^{-8}$

That is, counter E. M. F. is proportional to flux and speed. Substituting (2) in (1),

(3) $E = k\phi N + R_A I_A$ or

(4) $I_A = \dfrac{E - k\phi N}{R_A}$ or

[4] In this experiment the motor is assumed to be supplied with a constant impressed voltage. Motors are occasionally operated with constant current supply.

[5] E_c is in reality equal and opposite to the counter E. M. F.; in other words, it is that part of E necessary to overcome the counter E. M. F.

[6] See experiment on Shunt Generator, SCHOOL SCIENCE AND MATHEMATICS, Vol. XVII, No. 2, 1917.

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$$(5) \qquad N = \frac{E - R_A I_A}{k\phi}$$

The value of the mechanical force discussed above, which a conductor conveying a current experiences when moving in a magnetic field, is liH dynes, when l is the effective length of the conductor in centimeters moving at right angles to its length, i is the current in c. g. s. units and H is the strength of the magnetic field in lines per square centimeter. Since torque, or the moment of a force about any point or axis, is defined as the product of the magnitude of the force and the distance from the point or axis under consideration, taken perpendicularly to the direction of the force, the torque which liH produces about the motor shaft is liH.r dyne-centimeters, where r is the mean radius of the armature in centimeters.

Consider the force liH exerted upon one conductor through one complete revolution. The work done is $liH \times 2\pi r$ ergs = torque $\times 2\pi$, where 2π is the angle turned through in radians. In N revolutions, the work done is torque $\times 2\pi \times N$; and if N = R. P. S., since power is defined as work done per second, the power P may be expressed as follows:

Power (P) = torque (T) $\times$ total angle ($2\pi N$) turned through in one second

$$= \text{torque} \times \text{speed} \times \text{constant}$$

that is, torque is directly proportional to power and current and inversely proportional to speed. If P is expressed in H. P., T in pounds at a foot radius, and speed in R. P. M.,

$$(6) \qquad T = 5251 \frac{\text{H. P.}}{\text{R. P. M.}}$$

$$(7) \qquad T = 70.5 \frac{\text{watts}}{\text{R. P. M.}}$$

C. Discussion of Equations (4) and (5).

If a motor during operation is suddenly required to deliver a greater load, if the driving torque is insufficient, the motor will slow down. By means of equation (4) it is seen that, E and R_A being constants, a decrease in N will cause I_A to increase. Therefore, a larger armature current flows to produce the necessary greater torque to supply the larger output demanded of the motor. Under the condition of decrease in speed, E_a becomes less, and consequently the impedance to the flow of armature current is less than before. Likewise, in case I_A is too large for the load required, the driving torque, being also too

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large, will cause the armature to revolve with continuously increasing speed, thereby causing N and E_c to become correspondingly larger. This larger value of E_c reduces I_A to exactly that value which will produce the necessary driving torque. Thus is seen how I_A automatically increases and decreases with increase and decrease respectively in load.

The various methods of controlling the speed of a motor are easily understood by reference to equation (5) and are as follows: The impressed voltage E may be varied: a regulating rheostat (in addition to the starting rheostat mentioned later, Part II, A) may be placed in series with the armature circuit, and by varying the resistance, R_A may be correspondingly varied; the flux, ϕ, may be changed either by varying the field current I_F by means of a rheostat in series with the shunt field winding, or with the field excitation constant, ϕ may be changed by offering greater or less resistance (reluctance) to the path of the magnetic flux. This is accomplished by a device which moves the field magnets farther from the armature, so as to increase the air gap, or vice versa, as the conditions demand. In the directions below, Part IV, C, the speed of the machine is varied by changing E.

The flux must never be reduced to a dangerously low value so that the motor will "race." For this reason the field must always be fully energized before the motor is started. Furthermore, during operation, the field circuit is always to be left closed.

PART II. OPERATION.

A. Starting and Stopping.[7]

Connect the motor to be operated as indicated in the accompanying diagram, Fig. 3. See that the field rheostat is set for zero resistance, and the starting armature rheostat for maximum resistance. A large field current is desirable in order to "stiffen" the field and thereby limit the speed, as discussed above. On starting, the armature is at rest and therefore E_c is zero. In order to limit the armature current to a safe value, a larger starting resistance is inserted in series with the armature, which is gradually cut out as the armature comes up to speed. Having made the proper connections, close the main switch and bring the armature up to speed by gradually cutting out the starting armature resistance. The speed may yet be further

[7] See appendix to Shunt Generator experiment, SCHOOL SCIENCE AND MATHEMATICS, Vol. XVII, No. 2, 1917, for general directions on practical operation of dynamos.

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increased by slowly increasing the field resistance until rated speed is obtained.

In order to stop the motor, increase the starting armature resistance from zero to the maximum value and open the main switch.

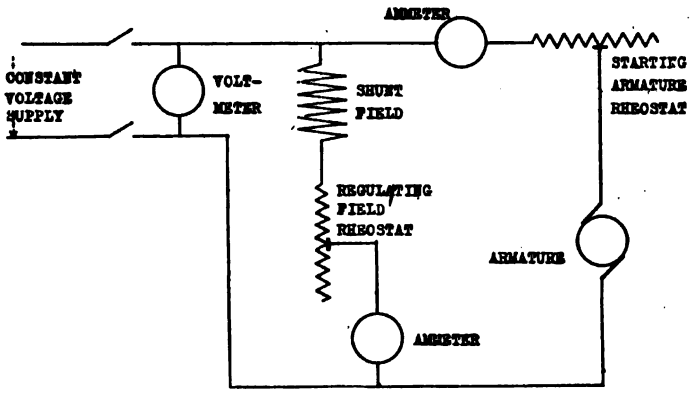

Figure 3

B. Questions.

1. In starting, why must the field circuit be closed *before* the armature circuit?
2. Why is a stiff or strong field necessary for starting?
3. Answer the same question with respect to starting under load.
4. How is the field current varied to increase and decrease the speed? Why?
5. Why is it dangerous to break the field circuit?
6. Why must the starting rheostat be connected in series with the armature and not with the line?

PART III. SPEED CHARACTERISTIC.

A. Data.

With the motor connected as indicated in Fig. 3, let the rated E. M. F. be impressed upon the brushes, and let this remain constant throughout the run. Also adjust the shunt field current I_F so that the motor runs at rated speed under no load. This value of I_F is to be maintained constant. Now by means[8] of drawing larger and larger current from a suitable generator belted to the motor, cause the motor load to vary from zero to full load, and in each case observe E, I_F, I_A and speed.

B. Curve.

Plot a curve with values of I_A as abscissa, and value of speed expressed in R. P. M. as ordinates. See Fig. 5.

[8] The load on the motor may also be varied by a brake or a blower.

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PART IV. EFFICIENCY BY MEANS OF MEASUREMENT OF LOSSES.

A. Classification of Losses.

Efficiency of a motor may be defined as the ratio of the energy output to the energy input. In many cases, especially with respect to motors of large capacity, it is inconvenient or undesirable to measure the energy output.[9] Under these conditions the motor losses are determined and are then subtracted from the input to give the output. Therefore

$$\text{Efficiency} = \frac{\text{Input} - \text{losses}}{\text{Input}}$$

The losses of a motor may be classified as follows:

- Losses
  - Copper losses
    - Armature copper loss $R_A I_A^2$
    - Field copper loss $R_F I_F^2$ or EI_F
  - Rotation losses or stray power
    - Core or iron losses
      - Eddy current loss
      - Hysteresis loss
    - Friction or mechanical losses
      - Air friction or windage
      - Bearing friction
      - Brush friction

Both R_A and R_F are to be determined by the fall of potential method[10] when hot. Knowing I_A and I_F, the total copper losses may be readily found by computation.

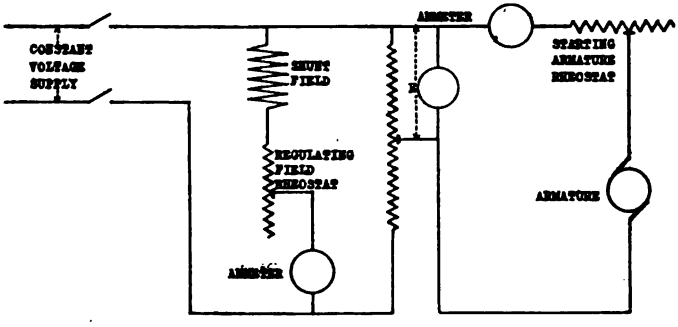

Figure 4

The magnitude of the core losses is independent of the motor load, depending only on the speed and the maximum flux density. At constant flux density, which in turn demands constant

[9] The output of a motor may be determined directly by electrical measurement by means of using a *belted* calibrated generator as load; or by mechanical measurement by means of determining torque by a Prony brake or Brackett cradle dynamometer. Power output is equal to the product of torque, speed, and a suitable constant. Compare equation (6) above. For a description of the Prony brake, see *Standard Handbook for Electrical Engineers*, 1915, pp. 192, 637. For a description of the cradle dynamometer, see *Standard Handbook for Electrical Engineers*, 1915, p. 195.

[10] See appendix, Shunt Generator experiment, loc. cit.

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field excitation or constant value of I_F, the eddy current loss varies directly with the square of the speed, and the hysteresis loss varies directly with the speed.

The friction losses are also approximately independent of load and vary directly with the speed.

In order to determine the efficiency by the measurement of losses, two runs are made: the load run, to determine the working conditions, and the no-load run, to determine the losses under these same working conditions.

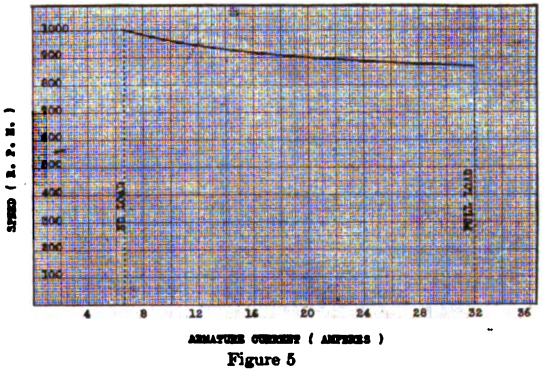

Figure 5

B. No-load Run.

1. Data.

The machine is driven electrically, according to the diagram of connections outlined in Fig. 4.

With constant field current, adjusted so that the motor runs at rated speed at no-load, vary the impressed voltage, E, from the rated value to approximately one-half rated value by ten equal steps, in each case measuring E, I_F, I_A and speed.

2. Losses.

With respect to the no-load run, the entire energy input is consumed in the losses of the machine. The total copper losses are computed as explained under Part IV, section A. The input, $E(I_A+I_F)$, minus the total copper losses, equals the rotation losses, W_o.

The results are to be tabulated as follows:

No-load Run.

Impressed voltage E	Current: Armature I_A	Current: Field I_F (constant)	Current: Line current $I_L = I_A+I$	Input EI_L

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Copper Losses			Rotation Losses
Armature $R_A I^2_A$	Field EI_F	Total $R_A I_A^2 + EI_F$	$W_o = EI_L$ – total copper losses

Speed R. P. M.	Torque[11] = $\frac{W_o}{\text{R. P. M.}}$

3. Curves.

The following two curves are to be plotted: with speed expressed in R. P. M. as abscissas, plot value of W_o as ordinates for one curve, and values of torque for the second curve. The values plotted are found in the last three volumes of the preceding data table. See Fig. 6.

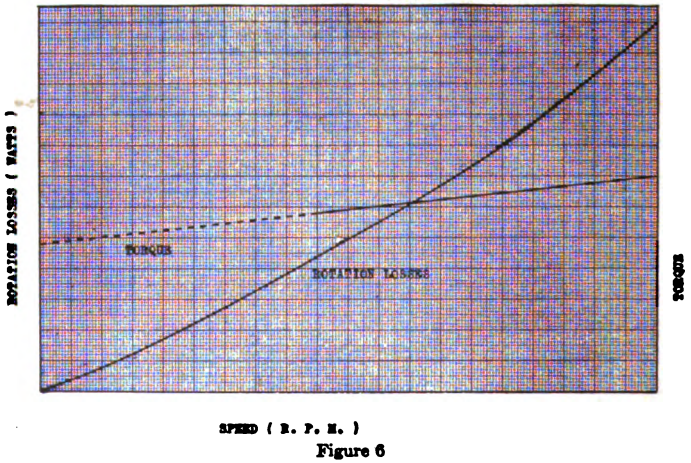

Figure 6

C. Load Run.

1. Data.

This run is identical with the run described to determine the speed characteristic. See Part III, A. The data for the load run is to be tabulated as follows:

Load Run.

Impressed voltage E (constant)	Current: Armature I_A	Current: Field I_F (constant)	Current: Total $I_L = I_A + I_F$	Input EI_L

[11] Torque, as determined by the equation, is expressed in a unit called the "synchronous watt," if W_o is expressed in watts.

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Copper Losses				
Armature $R_A I_A^2$	Field EI_F	Total $R_A I_A^2 + EI_F$	Speed R. P. M.	Rotation losses W_o[12]

Total losses W_o + copper losses	Output[12] Input − total losses	Efficiency = output / input	Torque = W / R.P.M.

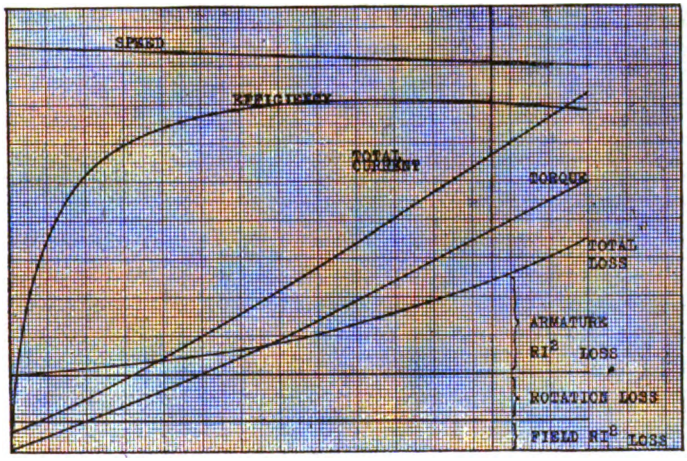

Figure 7

2. Curves.

By means of the tabulated data, plot the following curves, in each case using values of power output or, more simply, armature current I_A as abscissas; field copper loss, armature copper loss, rotation losses, total losses, output, input, efficiency, total current, speed (already plotted under Part III, B), and torque. See Fig. 7. Interpret all the curves.

Part V. Appendix.

References.

Bedell and Pierce: "A. C. and D. C. Manual," 1914, pp. 25-35, 37-38, 41-49.

Franklin and Esty: "Elements of Electrical Engineering," 1906, vol. 1, pp. 95-116, 123-124, 127-128, 129-132, 138-139, 141-144, 172-175, 383-386, 408-410, 412-415.

Gray: "Principles and Practice of Electrical Engineering," 1914, pp. 78-90, 95-99, 105-113, 371, 373, 374.

[12]Obtained by reference to curve, Fig. 6.

Fifty cents each will be paid for back numbers Vol. II, No. 3, May 1902.

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A MODERN QUEST FOR THE PHILOSOPHER'S STONE.

IN THE REALM OF TEACHING THE SECONDARY SCHOOL SCIENCES.

BY HERBERT BROWNELL,

University of Nebraska, Lincoln.

At the 1917 meeting of the Central Association of Science and Mathematics Teachers a committee was continued to consider the question of "Science in the High School of Tomorrow." In SCHOOL SCIENCE AND MATHEMATICS of June, 1917, this committee asked the assistance of all science teachers in the solution of certain named "problems," among which are to be noted:

A "unified" four-year course for secondary schools in contrast with "a train of specialized sciences."

"A unifying principle for such a course."

"The formulation of an aim, or aims, in the teaching of a unified science course."

"A minimum list of topics from each specialized science for incorporation into the course in introductory science." (Of these specialized sciences, *seventeen are named by way of suggestion.*)

In this further effort at the hands of this very competent committee, science teachers generally should be enough interested to offer suggestions as requested. Their assistance is invoked to the end that the continued search for this educational Philosopher's Stone may yield much in the teaching of secondary school sciences in the way of by-products, though it fail in its main purposes as set forth above.

Science teachers are wont to feel more or less indulgent in their discussions of the labors of those whose names are associated with the beginnings of chemistry as they sought to attain the transmutation of metals. We, too, feel ourselves rather superior in our greater enlightenment as we retell the story of the search for the Fountain of Perpetual Youth. We magnanimously allow that out of these efforts of alchemist and traveler have come much of progress in science and in civilization as by-products of efforts made by them.

Out of discussions, now largely forgotten, in the meetings of science teachers, from numberless papers and published articles containing the results of efforts much like that proposed by this committee, it would seem at first thought that little of lasting value has ever come. Nevertheless, in a community of interests established and in a unification of effort for the solution of the common problems of teachers of science in secondary schools, there is, indeed, a promise of gain worth all the time and pains of the committee and of those who respond to its call for suggestions and assistance.

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The writer desires in this connection to express the belief that much of the lack of complete success heretofore, of attempts to unify the secondary school sciences and the root of much of the failure charged against them, *lies in choice of a unifying principle.* It is, perhaps, somewhat trite to say that the personality and preparation of teachers, the varied experiences and different natures of pupils, and the widely different conditions under which instruction in science in high schools occurs, are all variable factors in a problem *the solution of which can never be more than an approach to a constant.* To ignore these variables in any choices of topics made from the differentiated secondary school sciences is to court failure in practice. The unifying element for beginners in science must ever be the human element. As such, the problem is ever a difficult one, and the solution of it impossible of reduction to any system free of weaknesses that threaten its destruction. College and university science teaching is expected to be scientific in its presentation, and "science for its own sake." But in elementary science teaching the facts, phenomena and theories *are but material for the teaching of "folks."* It is the difficult task of the high school teacher to know when and how to bring about a transition in the spirit and procedure of science teaching from the objective to the subjective, from the inductive to the deductive.

One of the chief products of long continued efforts through committees to attain better results in science teaching has been an ever enlarging recognition of the fact that in all diversities of subject matter and in all methods of instruction in the various science branches there is to be found, in teaching them to high school boys and girls, a real unity *in the common interests and experiences of youth.* One common aim and end in the teaching of them all is the attainment of a scientific attitude of mind and a scientific procedure in all affairs of life. To organize the teaching of secondary school sciences on any plan which does not recognize as fundamental such choices of subject matter as shall arouse in pupils *a desire to know more,* which fails to stimulate and direct aright such desires with largest effectiveness, is to fall far short of a possible goal. Perhaps nowhere in the educational system is there so great need of skilled teaching as in the secondary school sciences. Success or failure in training each generation of youth to become intelligent observers of their surroundings in the natural world, capable of interpreting and applying in a scientific way the facts of experiment and of

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observation, *requires as teachers* those who can quicken and direct the thinking of pupils, and in the routine of laboratory and classroom can secure the formation of study habits making of these pupils lifelong students. The quest for such teachers in sufficient numbers for the public school service goes on unendingly—a search for a human agency whereby untrained minds may be helped to acquire much of scientific capabilities and powers through studies in elementary science. No set of outlines, no selection of topics from the various divisions of secondary school science, however wisely chosen and combined, can be a substitute for a teacher who guides and inspires, one competent primarily *to teach folks as distinguished from teaching subject matter*. Herein is the handicap of the specialist in any science, and reason for his inability oftentimes to make lifelong students out of his high school pupils. Not enough attention, by far, is being given by science committees and science organizations to a quest for competent teachers of high school sciences to fill ranks depleted season by season. It seems to be taken for granted that in some unexplained manner such teachers will spring up out of the ranks or "grow up," even as did Topsy. No mechanism of outlined topics, of text and of manual, will accomplish what is desired in elementary science teaching in the hands of indifferently prepared teachers.

However, with all this emphasis placed upon the aims of the beginning phases of science teaching, and of the procedure necessarily followed to accomplish these aims, what the committee proposes to undertake is none the less important. This is especially the case in view of the need of an orderly transition from a science teaching that seeks primarily to get classes of pupils "to want to know" the teachings of science, and able to formulate and solve their own particular problems in life by reason of their science studies, to those later and more advanced stages where knowledge is presented and tested according to accepted theories, regardless of whether or not it has for the student any considerable measure of interest, of personal experience, or of application to his daily round of life.

The writer believes that a most helpful contribution was made not so very long ago to what this committee has under consideration, at least so far as the beginning stages of secondary school science is concerned, in a Bulletin published by the Massachusetts State Board of Education on "The Teaching of General Science." It is a manual of fifty pages for use of the teachers

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of this late arrival in the list of high school science subjects, and sets forth admirably the spirit and aims of elementary science teaching. It can be made to serve as a starting point for the labors of this committee.

CONTAINERS FOR INSECTS AND BIRDS TO BE USED FOR CLASS WORK.

By Hattie J. Wakeman,

Zoological Laboratory, University of Wisconsin.

Though dried insects and bird skins offer excellent material for laboratory study in general biology, entomology, and parasitology courses, the best specimens usually cannot be put in the hands of students because they will be injured by careless treatment. In this laboratory we have lately used two schemes which obviate this difficulty and permit the use of the most valuable specimens by elementary classes.

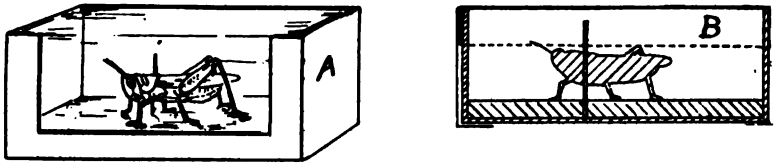

Figure 1

For insects a pasteboard box (Fig. 1) is made of appropriate size. This has a bottom of sheet pith, which receives the pin bearing the insect. Two sides and the top of the box are covered with sheet celluloid as glass plates and this allows students to examine the venation of wings and other details which require

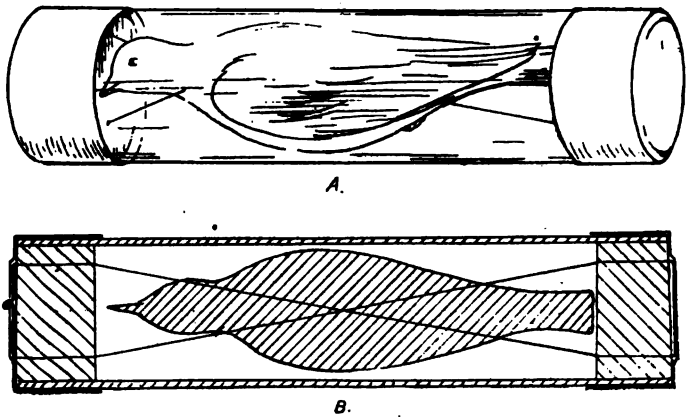

Figure 2

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the use of a hand lens. Ordinary insect pins will need to be cut off above the specimen in order to bring it close to the cover. The pith, pasteboard, and celluloid are firmly fastened together with passe partout, which also seals up the box and prevents the entrance of dermestids. If a drop of chloroform is placed in the box before it is closed, there need be no worry concerning the insect pests which so often destroy dried specimens.

Mr. A. H. Conrad, of the Crane High School, Chicago, devised an excellent method of preparing bird skins for class use (Fig. 2). Fine wires are threaded through the skin so that it can be fastened to corks in the ends of a glass tube of proper size to make a snug fit for the skin. A little chloroform is placed on the skin and the ends of the tube are sealed with passe partout.

Fig. 1. Insect box with two sides and top made of sheet celluloid or glass. A, entire box; B, section.

Fig. 2. Bird skin enclosed in glass tube for class work. A, entire preparation; B, section.

PHARMACY AS AN AMERICAN RED CROSS AID.

Pharmacy and the science of healing have played a large and invaluable part in the war, and the American Red Cross has made ample use of both in the service which it is rendering to humanity on behalf of the American people, whose steward it is. Essentially an agent of service, the Red Cross work originally was confined to hospitals, where the pharmacist and the surgeon worked hand in hand. Now that the scope of the Red Cross has taken in humanitarian efforts—the feeding of the hungry, the clothing of the naked and the housing of the homeless—the pharmaceutical-surgical side has been more or less overlooked by the public, yet it is as important as ever. It means the saving of lives and the rehabilitation of society.

The extent of the pharmaceutical side of Red Cross service may be gleaned from the fact that during the last few months it has shipped overseas 231,000,000 surgical dressings; that every month 1,000,000 pounds sterilized gauze and 10,000 pounds of ether go "over there." To date, the Red Cross has sent 10,637,201 hospital garments and 8,203,120 packages of hospital supplies.

Further evidence is shown by the supply of drugs and chemicals the Red Cross has bought within the last few months: 1,101,000 Greeley units of strychnine and morphine sulphate; 120,000 pounds nitrate ammonium; 390,000 pounds ether;

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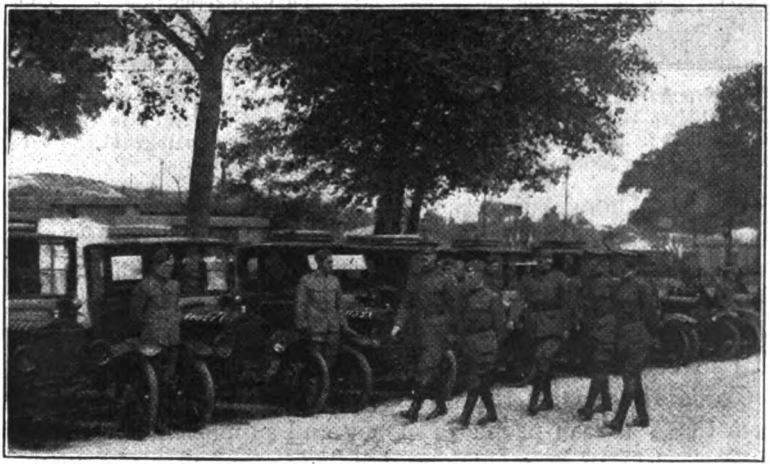
300,000 cathartical compositae pills; 52,500 pounds chloroform; 583,523 vials anti-tetanous serum; 640,000 sulphonol tablets; 11,000,000 strychnine sulphate tablets; 770,000 tablets of sodium salicylate and 350 ounces of apothesin.

Typical condition of a village in France when the American Red Cross starts its reconstruction work.



Major Perkins, Red Cross Commissioner for Europe, on the left, inspecting the American Red Cross transportation service.

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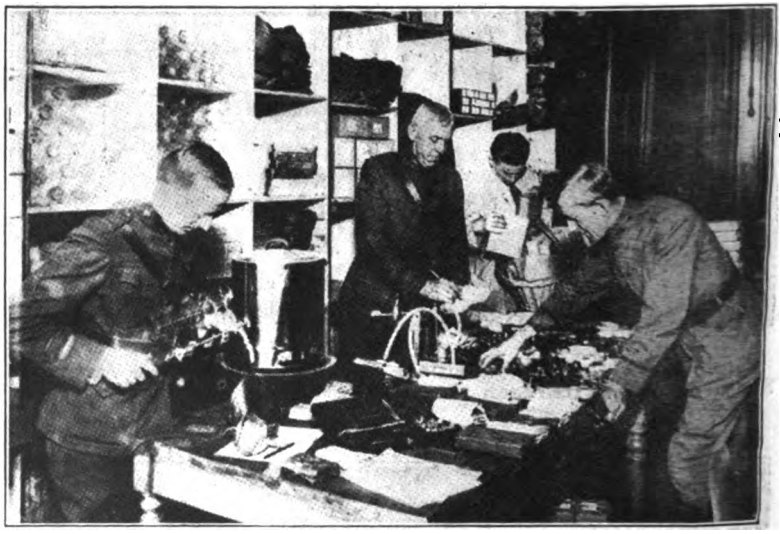
This and much other quantity of drugs was used in Red Cross hospitals in France and elsewhere. Appropriations of the Red Cross for hospitals within the actual fighting zones amounted to $3,102,807 this year. Hospitals behind the lines and supplies cost $5,874,392. The equipment of civil hospitals for Belgian refugees in France cost $59,962. There are more than 7,000 beds available for American wounded in and about Paris. Many thousands of beds in tents, hospitals and in temporary buildings are right behind the advancing battle lines. There are six dispensaries and eight infirmaries at rest stations. There are eight convalescent homes for American soldiers.



At the American Red Cross laboratory, 10 Rue de Tilsitt, Paris. Assembling Burlingame units to send to the Front. The Burlingame unit is a box containing an emergency set of surgical instruments for surgeons behind the lines. July, 1918.

The Red Cross is operating eight hospitals on its own account and in connection with the army. In addition, it operates a tuberculosis sanitarium for soldiers, another similar institution for civilians and has a dozen hospitals for children in various parts of France. Then, too, it has dispensaries and diet kitchens and sixteen magnificently equipped hospital trains.

To date the Red Cross has received more than $325,000,000 from the American people in money and supplies. The service of the Red Cross is broadening daily as the number of our men overseas is increasing, as thousands are repatriated, as French and Belgian and Balkan territory is reclaimed. The Red Cross

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must continue its service work for humanity. To do so it must have the united support of the American people. Accordingly it has set aside the week of December 16 to 23 for its second annual Christmas Roll Call. It is hoped that then every American will become a member of the Red Cross as a reconsecration of the people, an inspiring reassertion to mankind that in this hour of world tragedy, not to conquer but to serve is America's supreme aim.

PICRIC ACID MANUFACTURE.

By HARRY C. DOANE,
Grand Rapids.

Picric Acid

To manufacture picric acid, phenol, commonly cald carbolic acid, is dissolvd in sulfuric acid. These react as follows:

$$C_6H_5OH + H_2SO_4 = C_6H_4(SO_3H)OH + H_2O$$

Phenol — Sulfuric Acid — Phenol-Sulfonic acid — Water

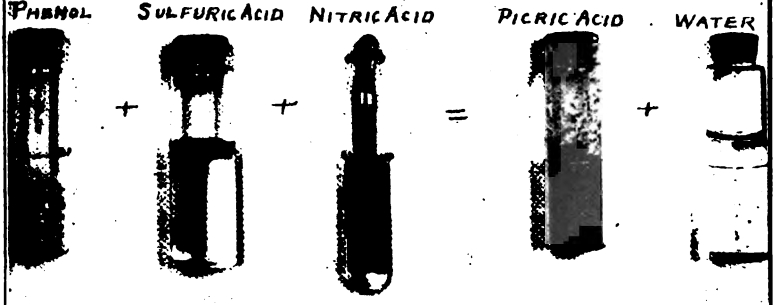
The product of the above action is treated with nitric acid, and the following action takes place:

$$C_6H_4(SO_3H)OH + 3HNO_3 = C_6H_2(NO_2)_3OH + H_2SO_4 + 2H_2O$$

Phenol-Sulfonic acid — Nitric Acid — Picric Acid — Sulfuric Acid — Water

Picric acid consists of bright yellow crystals. It and its ammonium salt (ammonium picrate) are used as explosive, mainly in filling shells, and the acid is used as a dye.

Neither picric acid or the ammonium salt is easily exploded on heating or by ordinary shocks. It is exploded by a violent shock caused by the explosion of a cartridge fild with fulminate of mercury, cald a detonator. The detonator is exploded by means of a fuse.



Sulfuric acid is also formd again, and is left over at the end of the action.

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A MODEL OF SUPPLEMENTARY TRIHEDRAL ANGLES.

By R. M. Mathews,
Duluth, Minn.

When the vertices of a spherical triangle are joined to the center of a sphere, a trihedral angle is determined whose face angles are measured by the sides and whose dihedral angles are measured by the angles of the spherical triangle. The two figures may be called "related." Each property of a spherical triangle implies a corresponding property in the related trihedral angle. Conversely, when a trihedral angle is placed with its vertex at the center of a sphere, its edges cut the surface in the vertices of a related spherical triangle.

Let a perpendicular be erected to each face of a trihedral angle at the vertex and on the same side as the third edge. These three new lines determine a new trihedral angle which is called "supplemental" to the first. The related spherical triangles of these trihedral angles are polar triangles, and each property of one pair implies a corresponding property in the other pair.

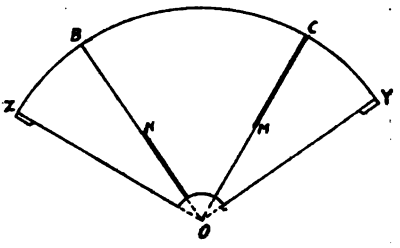

Figure 1

The geometry of polar triangles is a regular part of our courses in solid geometry. The geometry of supplemental trihedral angles has been neglected until recently, when they have been introduced in some of the newer texts. The chief difficulty in studying them lies in obtaining a clear image of the relative positions of the lines and in making the perspective diagrams. I have found that one recitation devoted to planning the construction of a cardboard model is fully justified by the pupils' resulting clearness of conception and firmer grasp on the many principles used in the work.

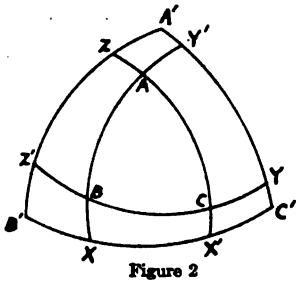

Figure 2

The model consists of two main parts, one for each of the trihedral angles. It is evident how to construct a trihedral angle in cardboard when its three face angles are known. Convenient dimensions are 4 inches for radius of sphere (or edge) and $a = 65°$, $b = 55°$,

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$c = 50°$ for the face angles of the initial figure. Each face must have extensions on it, however, to hold it in proper position. To make face a, construct a sector BOC (Fig. 1) with an angle of 65° and a radius of 4 inches. Lay out a right angle COZ′ on the same side as OB, and right angle BOY on the same side as OC. Cut slots CM and ON half the length of the edges and equal in width to the thickness of the cardboard. Around 0 cut out a sector of 1-2 inch radius, to make the assembling easier, and leave small lugs at Y and Z′. In a similar fashion faces b and c are prepared and the three are assembled. It is well to mark the six corners (as X, X′, etc.) with the notation indicated in Fig. 2, for guides when this part is placed in the other one.

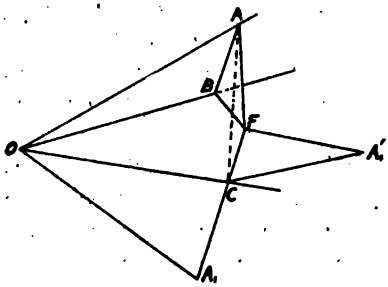

Figure 3

The face angles of the second trihedral angle are supplementary to the opposite dihedral angles in the initial trihedral. We must determine these. Through a point A on edge OA pass two planes, the one orthogonal to edge OB and the other to edge OC of the trihedral angle (Fig. 3). These planes intersect in a line AF which is normal to face BOC. Accordingly, triangle AFC, is right angled at F and its angle C is a plane angle of the dihedral OC.

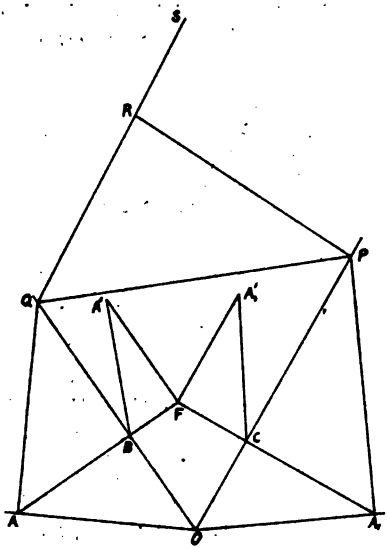

Figure 4

When this figure is folded out on the plane of OBC, the constructions are evident (Fig. 4). We lay out angles AOB, BOC and COA_1 equal to the initial angles respectively. Take $OA = OA_1$. Draw AB perpendicular to OB and A_1C perpendicular to OC meeting at F. Construct a right angle at F and make $CA'_1 = CA_1$. Then angle FCA'_1 is the plane angle of dihedral OC, and $A'CA_1$ is its supple-

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ment. Similarly, angle ABA′ is obtained. The supplement for dihedral angle OA can be obtained by a like construction, or more quickly as follows: Erect a perpendicular to OA_1 at A_1 to cut OC at P; and a perpendicular to OA at A to cut OB at Q. Make triangle PQR with PR = PA and QR = QA. Angle PRQ is the plane angle of dihedral OA and angle PRS, its supplement, is the desired angle.

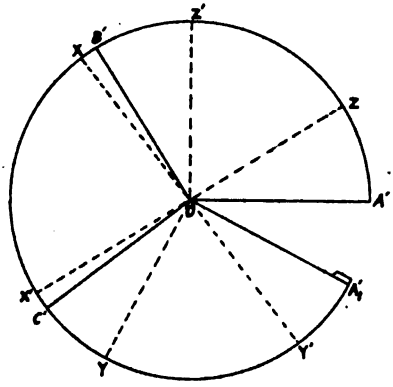

Figure 5

These three supplementary angles are the face angles of the new trihedral. Lay them out consecutively as A′OB′, B′OC′, C′OA′₁, and cut out the sector A′OA′₁ with a lug at A′₁. Draw lines OX perpendicular to OC′, OX′ perpendicular to OB′, and so on as indicated by Fig. 5 following the notation of Fig. 2. Crease along OB′ and OC′ and fasten together at A′A′₁. Now the two parts can be assembled and the model completed.

Should the class contain a boy with the requisite mechanical skill, this model can be used as a pattern for a still better one made of wire.

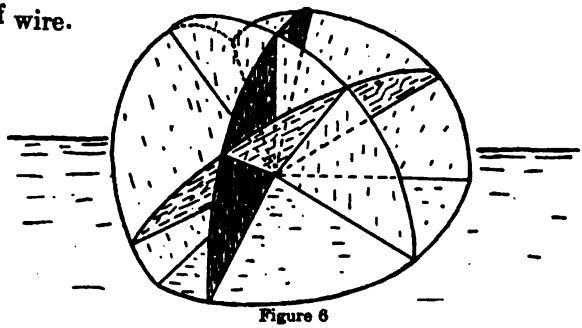
Figure 6

The angles as given here have been chosen so that the face angles on the second trihedral angle are each obtuse. When one of them is acute, certain difficulties arise in that a face of the first part intersects a face of the second part before it reaches the face to which it is normal. Again, when the initial angles are such that F falls, not in angle BOC but in its vertical angle, certain modifications of procedure are necessary. These difficulties can be surmounted without much trouble; to discuss them here would complicate a first presentation too much.

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PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.
Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

571. *Proposed by Harold M. Lufkin, St. Andrew's School, St. Andrew's, Tenn.*

Solve: $2\sqrt{2x+2}+\sqrt{2x+1} = \dfrac{12x+4}{\sqrt{8x+8}}$.

No communications concerning this problem were received. The problem as it is stated has no solution. If cleared of fractions and radicals the value $x = 1/7$ is found, which does not satisfy the equation. If the second radical is replaced by $-\sqrt{2x+1}$, $1/7$ is a root.—*Editor.*

Geometry.

572. *Proposed by Takeshi Omachi, Sendai, Japan.*

Catalan's Theorem: In a quadrilateral ABCD, if the sides AB and CD are equal to each other, the straight line MN passing through the middle points M and N of the sides BC and AD will equally incline to the sides AB and CD.

I. *Solution by Philomathe, Montreal, Canada.*

Draw NE equal and parallel to AB, also NF equal and parallel to CD. Join BE, EF, FC; EF passes through M and EM = MF (BEFC a parallelogram). Hence, in the isosceles triangle ENF, the line MN bisects the vertical angle N, that is MN is equally inclined to AB and CD.

II. *Solution by A. MacLeod, Aberdeen, Scotland.*

Draw AP, BQ, CR, DS perpendicular to MN, AK perpendicular to BQ, and DH perpendicular to CR.

From triangles APN, DSN, AP = DS $\therefore$ KQ = HR.

From triangles BQM, CRM, BQ = CR $\therefore$ BK = CH.

From triangles BAK, CDH, $\angle$BAK = $\angle$CDH, and these are the inclinations of AB and CD to MN.

Also solved by the PROPOSER, L. E. A. LING *and* R. M. MATTHEWS.

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573. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

From one of the angles of a rectangle a perpendicular is drawn to its diagonal, and from the point of their intersection straight lines are drawn perpendicular to the sides which contain the opposite angle. Show that if a and b be the lengths of the perpendiculars last drawn, and c the diagonal of the rectangle,

$$a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}.$$

I. *Solution by Philomathe, Montreal, Canada.*

Let m, n be the sides of the rectangle respectively parallel to b and a. Well known relations in the triangles give at once the equations,

$m^2+n^2 = c^2$, $bc/m^2 = m/c$, $ac/n^2 = n/c$.

Eliminate m and n from the system:

$bc^3 = m^3$, or $b^{\frac{2}{3}}c^2 = m^2$; $ac^3 = n^3$, or $a^{\frac{2}{3}}c^2 = n^2$; hence,

$a^{\frac{2}{3}}c^2+b^{\frac{2}{3}}c^2 = m^2+n^2 = c^2$, or $a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}$.

II. *Solution by A. MacLeod, Aberdeen, Scotland.*

Given: Rectangle ABCD, AO $\perp$BD, OE $\perp$BC, OF $\perp$CD.

To prove if OE $= a$, OF $= b$, BD $= c$, then $a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}$.

Let $\angle ABD = \theta$. Then $\angle DAO = \theta$.

OE $=$ OBcosθ $=$ ABcos$^2\theta$ $=$ BDcos$^3\theta$. $\therefore a = c\cos^3\theta$.

OF $=$ ODsinθ $=$ ADsin$^2\theta$ $=$ BDsin$^3\theta$. $\therefore b = c\sin^3\theta$.

$\therefore a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}\cos^2\theta+c^{\frac{2}{3}}\sin^2\theta = c^{\frac{2}{3}}$.

III. *Solution by L. E. A. Ling, La Grange, Ill.*

Given rectangle ABCD, DE $\perp$AC, EM $= b$ and $\perp$BC; EH $= a$ and $\perp$AB; HE intersecting CD in L, EL $= k$; ME intersecting AD in N, NE $= g$; AC $= c$.

From the right triangle ACD,

$$c^2 = a^2+2ak+k^2+b^2+2bg+g^2. \qquad (1)$$

Rectangle NELD is equal to rectangle EHBM.

$\therefore gk = ab$, also $g = \sqrt{ak}$, $k = \sqrt{bg}$. Then $k\sqrt{ak} = ab$, whence $k = a^{\frac{1}{3}}b^{\frac{2}{3}}$. Similarly, $g = a^{\frac{2}{3}}b^{\frac{1}{3}}$. Substituting these values for k and g in (1),

$$c^2 = a^2+b^2+3a^{\frac{1}{3}}b^{\frac{2}{3}}+3a^{\frac{2}{3}}b^{\frac{1}{3}}. \qquad (2)$$

Taking the cube root of (2),

$$c^{\frac{2}{3}} = a^{\frac{2}{3}}+b^{\frac{2}{3}}.$$

Also solved by R. M. MATHEWS, *who appends the following remark:*

"When a line of constant length moves with its ends on two rectangular axes it envelopes a curve whose equation is

$$x^{\frac{2}{3}}+y^{\frac{2}{3}} = c^{\frac{2}{3}}.$$

This problem furnishes a construction for the point of contact of the line with its envelope."

574. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

Construct a triangle ABC, having given the distances of its incentre, circumcentre, and orthocentre.

Solution by the Editor. (No solutions received.)

Let AI, AH, AO be given distances from vertex A of triangle ABC to incenter I, orthocentre H, and circumcentre O, respectively.

Lemma I. The distance AH is twice the distance from O to the side BC.

Lemma II. If R and r be the radii of the circumcircle and incircle, respectively, and d (=IO) the distance between the centers, $d^2 = R^2-2rR$.

Proofs of these lemmas may be found in Vol. XV, pp. 258, 259 (March, 1915), SCHOOL SCIENCE AND MATHEMATICS, if not elsewhere.

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Choose a point O as center and draw circumcircle with radius OA.

With radius AH/2 and center O describe circle which (by Lemma I) will be tangent to side BC. This lies within circumcircle, for the orthocenter of any triangle ABC is the circumcenter of a triangle A'B'C' formed by drawing lines through A, B, C parallel respectively to BC, CA, AB. Then, $AH < R'$ and $R' = 2R$, $\therefore AH/2 < R$. (R' circumradius of A'B'C'.)

Draw chord of circumcircle tangent to inner circle and choose this as side BC of the desired triangle. Angle A is thus determined.

Construct an angle equal to $\angle A$, bisect it, choose length AI on bisector, and drop perpendicular from I to one side determining r.

Construct d, a mean proportional between R and $R-2r$. (Lemma II.)

The intersection of a circle with radius d and center O with a line parallel to BC at the distance r from BC is the center I of the incircle. The intersection of a circle with center I and radius IA with the circumcircle will give the third vertex A of the triangle.

Proofs not contained in the statements are obvious.

575. *Selected.*

Prove this theorem from Wentworth-Smith's *Solid Geometry* (Exercises on Book VI) by means of earlier theorems.

If the face angle AVB of the trihedral angle V-ABC is bisected by the line VD, the angle CVD is less than, equal to, or greater than half the sum of the angles AVC and BVC according as CVD is less than, equal to, or greater than a right angle.

Solution by Philomathe.

In the plane CVD make angle DVC' equal to DVC. Trihedral angles V-ADC and V-BDC' are equal, hence angles BVC' and AVC are equal. Now, if angle $CVD < 90°$, the trihedral angle V-BCC' gives angle $CVC' < BVC' + BVC$, or $CVC' < AVC + BVC$, that is $CVD < 1/2(AVC + BVC)$.

Next, if angle $CVD = 90°$, CVC' is a straight line, then $BVC' + BVC = 180°$, or $AVC + BVC + = 180°$; hence $CVD = 1/2(AVC + BVC)$.

Finally, if angle $CVD > 90°$, then $CVC' > 180°$. Producing through V, AV to VA', BV to VB', and DV to VD', $CVD' < 90°$; hence $CVC' < CVA' + CVB'$ in trihedral angle V-A'B'C. $\therefore 360° - CVC' > (180° - CVA') + (180° - CVB')$, or $CVC'(reflex) > CVA + CVB$.

Also solved by L. E. A. Ling. *R. M. Mathews calls our attention to the fact that this was solved as No. 404 in January, 1915. The two solutions published then differ from the one above.—Editor.*

Explanatory Note—*Problem* 567.

Contributed by Philomathe, Montreal, Can.

567. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

In 1857-58, Catalan proposed the following problem: "To construct a triangle knowing its three bisectors." Nobody solved it. However, by analysis, Professor Barbarin proved that the solution depends upon an equation of the 12th degree! See *Mathesis*, 1896, pp. 143, 154; also *Intermediaire des Mathematiciens*, 1904, p. 229, Question 2771.

Now, No. 567 is correlative to Catalan's problem, and the solution of the former presupposes that of the latter. Therefore, I do not think the problem geometrically possible.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC, respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

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No solutions received. The Editor submits the following:

For the problem to have a unique solution, P and Q must be given. Assume the triangle constructed. Let M and N be points of intersection with BC of tangents at P and Q, respectively, and let O be the point of intersection of PM and PN. BM : MC = $k : l$, and BN : NC = $m : n$; PBM and NQC are right triangles; $\angle POQ = 180° - \angle A$.

We begin by constructing a figure A'P'B'M'O'N'C'Q'A' similar to the one desired.

On a given line B'C' determine points M' and N' so that B'M' : M'C' = $k : l$ and B'N' : N'C' = $m : n$. Describe semicircles (on same side of M'N') on B'M' and N'C' as diameters. If M' lies between B' and N' the tangents at P' and Q' intersect M'N' before intersecting each other. In this case draw an arc on M'N' (on side of M'N' opposite the semicircles) in which would be inscribed the angle $180° - \angle A$. P' will lie on semicircle B'M', Q' on N'C', and O' on arc M'N'. Our problem, then, is to determine two equal lines O'P' and O'Q' so that M' lies on O'P' and N' on O'Q'. Assuming this done, according to the conditions of the problem we have the following relations:

Choosing, for brevity, the notation $\alpha = \angle P'M'B'$, $\beta = \angle Q'N'C'$ (then $\alpha+\beta = \angle A$, given); $\rho = B'M'/2$, $r = N'C'/2$, $c = Q'N'$, $\gamma = P'M'$, $t = O'N'$, $\tau = P'M'$, $d = M'N'$, δ = projection of t on M'N'; then

$$\gamma+\tau = c+t. \tag{1}$$

$$t/2r = \delta/c, \tag{2}$$

$$\tau/2\rho = (d-\delta)/\gamma. \tag{3}$$

(By similar triangles)

$$\tau/\sin\beta = t/\sin\alpha = d/\sin A, \quad (\sin A = \sin[180° - (\alpha+\beta)]) \tag{4}$$

$$\tau\cos\alpha + t\cos\beta = d, \tag{5}$$

$$\cos\alpha = \gamma/2\rho, \quad \cos\beta = c/2r. \tag{6}$$

We use the last five equations to express γ, τ and c in terms of t. Since from (4),

$$\tau\sin\alpha - t\sin\beta = 0, \tag{7}$$

if we multiply (7) by $\sin\alpha$, (5) by $\cos\alpha$, add, reduce by addition formula for cosines, substitute values in (6) and transpose, we have

$$\tau = \gamma d/2\rho + t\cos A.$$

From (6) and (4),

$$\gamma = 2\rho\cos\alpha = 2\rho\sqrt{d^2 - t^2\sin^2 A} = 2\rho/d\sqrt{d^2 - t^2\sin^2 A} \tag{8}$$

Hence

$$\tau = \sqrt{d^2 - t^2\sin^2 A} + t\cos A \tag{9}$$

Eliminating δ from (2) and (3),

$$c = (2\rho r d - \tau\gamma r)/\rho t.$$

Substituting now the values of γ and τ from (8) and (9),

$$c = 2r/d(t\sin^2 A - \cos A\sqrt{d^2 - t^2\sin^2 A}). \tag{10}$$

Substituting the values of (8), (9), (10) in (1), we obtain, after some reduction,

$$t = \frac{2\rho + 2r\cos A + d}{\sqrt{\left(\frac{2\rho + 2r\cos A + d}{d}\right)^2 \sin^2 A + \left(\frac{2r\sin^2 A - d\cos A + d}{d}\right)^2}}$$

From this form t may be constructed although the work involves thirteen separate constructions by compass and ruler such as fourth proportional, sum of squares, finding a linear ratio equal to a ratio of squares, and making ratios to replace sinA and cosA.

With t as a radius and N' as center describe arc intersecting arc M'N' at O'. O'P' and O'Q' will be the equal tangents to the circle A' at the points P' and Q', respectively, and will determine the circle. If R' be

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the radius of this circle and R of the given circle, then the fourth proportional to R',R and A'B' will be AB, the side of the desired triangle. AC and BC may be constructed in a similar manner.

If N' lies between B' and M' the arc M'N' would be described on the same side of B'C' as the semicircles and a slight change of notation would be necessary to carry through the same argument for this case as for the preceding.

The Editor recognizes that this is a devious method and will welcome a simple one.

Late Solutions.

566. M. B. Messinger, Mehta Kanhyalal.

PROBLEMS FOR SOLUTION.

Algebra.

586. *Proposed by Philomathe, Montreal, Can.*

Solve, by Elementary Algebra:

$2x^2+\sqrt{x^2+9} = x^4-9.$

587. *Proposed by W. T. Harlow, Portland, Ore.*

A merchant takes $1,000 every year out of his income for personal expenses. Nevertheless his capital increases every year by a third of what remains. At the end of three years it is doubled. How much had he at first? (From Chrystal's *Algebra*.)

588. *Proposed by Daniel Kreth, Wellman, Ia.*

Given:

$y+\sqrt{y/x} = 42/x$ (1)

$x^2/3+x/2\sqrt{y} = 54/y$ (2)

Find x and y.

589. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

AB is a chord of a circle. Find a point C on AB, such that if tangents CD and CE be drawn to the circle, and if EF, parallel to AD, cuts CD in F, CD may be bisected at F.

590. *Proposed by Daniel Kreth, Wellman, Ia.*

AB is a chord in a given circle, bisected in C. DE and FG are any two chords intersecting each other in C; FE intersects AB in H, and DG intersects AB in K. Prove that CH = CK. Geometrical and trigonometrical solutions are desired.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

War Questions on Science.

310. What questions on science, new and old, has the war brought to our attention?

It will be most timely to give general circulation to such questions as

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have come to your attention, especially those which have introduced interesting discussions into your classes. Mail them to the Editor now.

Would you guess from current questions in science examinations that the past two years represent the most stupendous scientific development ever known?

The following list of questions speaks for itself:

COLLEGE ENTRANCE EXAMINATION BOARD.

Comprehensive Examination in Physics, Friday, June 21, 1918.

A teacher's certificate covering the laboratory instruction must be presented as a part of the examination unless the laboratory notebook is to be presented at a laboratory examination.

Answer ten numbered questions, distributed as follows: three from Group I, two from Group II, two from Group IV, two from Group V, and one of the remaining questions.

The number in parentheses before each question indicates the number of credits assigned to it.

Show clearly the method by which you obtained your answers to problems and state the units used in each case.

Attach to the answer, in each case, the number and letter used in the printed paper.

GROUP I.

1. A wooden cube 5 cm. on an edge weighs 100 g. (*a*) (3) What is the density of the cube? (*b*) (3) What force would be required to hold the cube submerged in a liquid having a density of 1.5 g. per cu. cm.? (*c*) (4) How much of its volume would protrude above the surface if the cube were floated in a liquid having a density of 1.2 g. per cu. cm.?

2. (*a*) (3) Define work; mechanical advantage of a machine; efficiency of a machine. (*b*) (7) Two men raise a weight by means of a jackscrew. They push with a force of 100 lbs. each, at opposite ends of a bar 5 ft. long that passes through a hole at the top of the screw. If the pitch of the screw is 1-2 inch and the efficiency of the machine is 30 per cent, how great is the weight?

3. An engine operates a pump which raises water to a height of 50 ft. at the rate of 1,000 gal. per min. (One gallon of water weighs 8.4 lbs.) (*a*) (3) How much work is done upon the water per second? (*b*) (7) If the efficiency of the pump is 90 per cent, how many horse-power is the engine developing?

4. A constant force acting on a mass of 40 grams for 5 seconds changes its velocity from 60 cm. per second to 100 cm. per second. What is: (*a*) (2) the acceleration? (*b*) (2) the magnitude of the force? (*c*) (2) the total distance covered in the five seconds? (*d*) (2) the final momentum? (*e*) (2) the kinetic energy at the end of the first two seconds?

5. (*a*) (8) A tank having a volume of 12 cu. ft. contains air under a pressure of 30 lbs. per sq. in. On connecting the tank to an exhausted receptacle the air pressure is reduced to 10 lbs. per sq. in. Find the volume of the receptacle. (*b*) (2) Describe two phenomena that are caused by surface tension.

GROUP II.

6. (*a*) (2) Define coefficient of linear expansion. (*b*) (8) Describe an experimental method of measuring the coefficient of linear expansion of a solid, describing the apparatus used, the measurements made, and the way in which these measurements are used to compute the coefficient.

7. (*a*) (6) A balloon is filled on a cool night with 20,000 cu. ft. of gas at a temperature of 7° C. under a pressure of 15 lbs. per sq. in. In the sunshine of the day the gas becomes warmed. At what temperature will the pressure reach 16 lbs. per sq. in.? Assume that the gas bag does not stretch and that no gas escapes. (*b*) (2) Express 9° C. on the Fahrenheit scale. (*c*) (2) Compare the advantages of mercury and of air as thermometric substances.

8. (*a*) (2) Name and define a unit quantity of heat. (*b*) (8) A copper calorimeter of mass 210 g. contains 85 g. of water and 100 g. of lead shot at 15° C. How much boiling water must be added to raise the temperature

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of the calorimeter and contents to 25° C.? (Sp. ht. of copper = 0.095; of lead = 0.032.)

GROUP III.

9. (*a*) (2) What conditions are necessary for the formation of an echo? (*b*) (2) What is the physical difference between a noise and a musical sound? (*c*) (2) Why is thunder usually heard some time after a lightning flash is seen? (*d*) (2) Upon what does the loudness of sound depend? (*e*) (2) Upon what does the pitch of a sound depend?

GROUP IV.

10. (*a*) (3) A more sharply defined shadow is cast by an opaque body when the source of light is an arc lamp than when it is a gas jet. Explain by the aid of diagrams. (*b*) (3) What should be the brightness of a single light in the ceiling 10 ft. from a book to give the same illumination as two candles placed one foot from the book?

(*c*) (4) Explain what is meant by saying that the index of refraction of water is 4/3. Make a careful, fully labeled diagram showing the passage of a ray of light obliquely from air into water.

11. (*a*) (2) Define principal focus; conjugate foci. A moving-picture machine is to be designed to project the picture on the film upon a screen 60 ft. from the film. If the image on the screen is to be 119 times the linear dimensions of the picture on the film: (*b*) (2) How far from the film must the projection lens be placed? (*c*) (4) What must be the focal length of the lens? (*d*) (2) How many times as intense will be the light passing through the film as that falling on the screen?

12. (*a*) (4) Make a diagram to show the dispersion of a narrow beam of sunlight by a triangular glass prism. (*b*) (4) What is the explanation of refraction? of dispersion? (*c*) (2) Explain carefully why the same blue cloth may seem to be of a different color when viewed by gaslight and by sunlight.

GROUP V.

13. (*a*) (2) What type of cell is best adapted to the ringing of electric bells? Why? (*b*) (2) What is meant by the term local action as applied to voltaic cells? (*c*) (2) How may local action be reduced? (*d*) (2) What is meant by polarization of cells? (*e*) (2) How may polarization be reduced?

14. Two resistance coils of 10 and 30 ohms joined in parallel are connected in series with a key, an ammeter of negligible resistance, and a battery whose electromotive force is 21 volts and whose internal resistance is 3 ohms. A voltmeter of high resistance is connected in parallel with the battery. (*a*) (2) Draw a diagram of the connections. (*b*) (2) What will be the ammeter and voltmeter readings when the key is open? (*c*) (6) What will the readings be when the key is closed?

15. (10) Describe the construction and operation of two of the following: electric bell; telegraph key and sounder; telephone receiver. Illustrate by carefully drawn diagrams.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for September; *27 King Street, Oberlin, Ohio:* "Definitions of the Discriminant of a Rational Integral Function of One Variable," G. A. Miller; "What is the Origin of the Name 'Rolle's Curve'?" Florian Cajori; "The Mathematics of Aerodynamics," E. B. Wilson.

American Naturalist, for August-September; *Garrison, N. Y.;* **$4.00** *per year*, **80** *cents a copy:* "The Relation Between Color and Other Characters in Certain Avena Crosses," H. H. Love and W. T. Craig; "Opisthotonos and Allied Phenomena Among Fossil Vertebrates," Roy L. Moodie; "Cancer's Place in General Biology," W. C. MacCarty; "A Survey of the Hawaiian Coral Reefs," Vaughn MacCaughey.

Astrophysical Journal, for September; *University of Chicago Press;* **$5.00** *per year*, **65** *cents a copy:* "The Visibility of Radiation," Edward

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P. Hyde, W. E. Forsythe, and F. E. Cody; "Studies Based on the Colors and Magnitudes in Stellar Clusters," Harlow Shapley; "The Absorption of Near Infra-Red Radiation by Water-Vapor," W. W. Sleator.

Auk, for October; *Cambridge, Mass.*; $3.00 *per year*, 75 *cents a copy:* "The Nesting Grounds and Nesting Habits of the Spoon-billed Sandpiper," Joseph Dixon; "A Winter Crow Roost," Charles W. Townsend; "The Pterylosis of the Wild Pigeon," Hubert L. Clark; "Sexual Selection and Bird Song," Chauncey J. Hawkins.

Blast Furnace and Steel Plant, for October; *Pittsburgh, Pa.*, $1.00 *per year;* 15 *cents a copy:* "Cement Gun Used in Repairing Pit Stacks, Characteristic of Automatic Engine Stops," Walter Greenwood; "Remote Controlled Sub-Station Described," W. T. Snyder; "Standardizing Large Rolling-Mill Motors," K. Pouly; "Electrically Driven Mills at Bethlehem," J. T. Sturtevant.

Condor, for September-October; *Hollywood, Calif.*; $1.75 *per year*, 30 *cents a copy:* "Notes on the Nesting of the Mountain Plover," W. C. Bradbury; "Evidence That Many Birds Remain Mated for Life," F. C. Willard; "Some Ocean Birds from Off the Coast of Washington and Vancouver Island," Stanton Warburton.

Geographical Review, for October; *Broadway at 156th Street, New York City;* $5.00 *per year*, 50 *cents a copy:* "The Geographical Barriers to the Distribution of Big Game Animals in Africa," Edmund Heller. (1 map, 14 photos); "The Outline of New Zealand," C. A. Cotton. (1 map, 7 diagrs., 11 photos); "The Slavs of Southern Hungary," B. C. Wallis. (3 insert maps in color, 1 text map, 1 diagr.); "The Activities of the Canadian Arctic Expedition from October, 1916, to April, 1918," Vilhjalmur Stefansson. (1 insert map.)

Journal of Geology, for September-October; *University of Chicago Press;* $4.00 *per year*, 65 *cents a copy:* "Permo-Carboniferous Conditions versus Permo-Carboniferous Time," E. C. Case; "Notes on the Geology of Eastern Guatemala and Northwestern Spanish Honduras," Sidney Powers; "Loess-Depositing Winds in Louisiana," E. V. Emerson; "Description of Some New Species of Devonian Fossils," Clinton R. Stouffer.

National Geographic Magazine, for August; $2.50 *per year; Washington, D. C.*: "Bringing the World to Our Foreign-Language Soldiers," with 4 illustrations, Christina Krysto; "Recent Observations in Albania," with 22 illustrations, Brig. Gen. George P. Scriven; "The Ukraine, Past and Present," with 14 illustrations, Nevin O. Winter; "The Acorn, a Possibly Neglected Source of Food," with 8 illustrations, C. Hart Merriam; "Our Littlest Ally," with 16 illustrations, Alice Rohe.

Photo-Era, for October; $2.00 *per year*, 20 *cents a copy; Boston, Mass.*: "Craft and Art in Amateur Photography," Edouard C. Kopp; "Proe and Kahn on Soft-Focus Lenses," August Krug; "Pictures that Appeal," H. B. Rudolph; "Pictorial Photography as I See It (In Three Parts—Part III)," C. W. Christiansen; "A New Plan for Salon-Hangings," Sigismund Blumann; "Trial-Exposures and Economy," British Journal.

Physical Review, for November; $6.00 *per year*, 60 *cents a copy, Ithaca, N. Y.*: "Note on the Reversal of the Corbino Effect in Iron," Alpheus W. Smith; "The Relation between Certain Galvanomagnetic Phenomena," C. W. Heaps; "The Photoluminescence and Kathodo-Luminescence of Calcite," E. L. Nichols, H. L. Howes and D. T. Wilber; "The Evaporation of Small Spheres," Irving Langmuir; "The Motion of an Electrical Doublet," Leigh Page; "Law of Motion of a Droplet Moving with Variable Velocity in Air," Raymond B. Abbott; "The Specific Heat of Tungsten at Incandescent Temperatures," Paul F. Gaehr.

Fifty cents each will be paid for back numbers Vol. II, No. 3, May, 1902.

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PERSONALS.

Mr. James H. Armstrong, for many years principal of one of Chicago's largest high schools, the Englewood, has recently been promoted to Assistant Superintendent in charge of Chicago's high schools. This is a most important position, one which has for many years been vacant to the great detriment of the high schools. No one in Chicago is better qualified in every particular to fill this most important position than Mr. Armstrong. This journal predicts a new era and all-round improvement in these schools under his management.

Mr. Franklin T. Jones, editor of Science Questions' Department in this journal, lately with the Glidden Paint and Varnish Company of Cleveland, has after many years again connected himself with the Warner and Swasey Company of Cleveland. Among other matters Mr. Jones will have charge of the development of an apprentice school into a junior engineering college.

Professor M. E. Grober has been elected to the chair of mathematics in Heidelberg University, Tiffin, Ohio.

Dr. W. O. Mendenhall, who has been professor of mathematics in Earlham College, has been made president of Friends' University, Wichita, Kansas.

Dr. E. L. Packard of the geology department at the Agricultural College of Mississippi has accepted a position in his chosen subject at the University of Oregon.

Dean Albert R. Mann, of the College of Agriculture at Cornell University, has been appointed by Governor Whitman a member of the state food commission.

Dr. Veranus A. Moore, head of the New York State Veterinary College at Cornell University, was elected president of the American Veterinary Medical Association at the Philadelphia meeting.

Professor George F. Freeman, of the College of Agriculture in the University of Arizona, has moved to Cairo, Egypt, where he will be connected with the Société Sultamenne de Agricultur.

Professor O. P. Jenkins, of the geology department of the State College of Washington, has been made geologist to the Arizona State Bureau of Mines, Tucson.

Professor J. W. Young, of Dartmouth College, has been made director of mathematics instruction in war work, given under the management of the Y. M. C. A.

Professor Edwin E. Hill succeeds to the position of director of the Jefferson Physical Laboratory of Harvard University, due to the retirement of Professor W. C. Sabine.

Dr. William P. Brooks has resigned from the position of director of the Massachusetts Agricultural Experiment Station, a position which he has held for nearly thirty years.

A SIMPLE "FALL" APPARATUS.

By A. H. Cooper,

Grove Park School, Wrexham, Eng.

The need for a simple and direct method of demonstrating to junior students the fact that a freely falling body moves with a constant acceleration, has frequently been felt by teachers of physics.

The apparatus described below has been in use by the writer for some five or six years, and has been of great service in making clear the laws of falling bodies to elementary students. It possesses the advantages that the whole apparatus is simple; an experiment is quickly performed;

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the motion of the falling body is traced absolutely from rest; from a single experiment it is easy to show with considerable accuracy that (*a*) the velocity is proportional to the time; (*b*) the distance fallen is proportional to the time squared; (*c*) the acceleration is constant, each of these being shown directly and independently; no assumption is made beyond that of the constancy of period of a vibrating spring; if the period of the spring is known, the value of g can be obtained with fair accuracy.

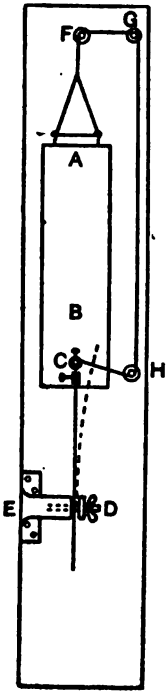

FIG. 1.

The essentials of the apparatus are shown in the diagram (Figure 1). The "falling plate," AB, consists of a board, 2 ft. by 4 in. by ¾ in. It is supported by a thread, with a loop passing under two screw-hooks in the upper edge of the board. The thread passes over long smooth nails at F, G, H, and terminates in another loop, which is placed over the brush-holder C, carried by the spring CD. On gently releasing the board, its weight, acting along the thread, deflects the spring slightly towards H. The spring is held in a clamp ED, screwed to the vertical back-board, and carries a small brush. The spring can be pressed over a little towards H, to give greater amplitude. A sheet of paper is previously pinned to the face of AB; the brush is now inked, and the thread burnt by a taper applied between G and H. Board and spring start moving at the same instant, and a curve similar to the one shown in Figure 2 is obtained. A frequency of from 15 to 20 is suitable for the spring, and this can be readily adjusted by means of the clamp.

The displacement, velocity, and acceleration of the falling body can now be obtained from the curve, for any stage of the motion; calling the period of the spring, for convenience, one second, the displacements after 1, 2, etc., seconds are given by AB, AC, AD, etc.; the corresponding velocities, however, are not given by AB, BC, etc., but by GH, HK, etc., since GH represents the distance traversed in one second, at the middle of which the body was at B, i. e., had been falling for one second; similarly, the velocity after two seconds is given by HK, and so on. The accelerations are given by GH, HK—GH, etc.

The following results are taken from an actual experiment:

t	s	v	a	s/t^2	v/t
1	1.6	3.35	3.35	1.60	3.35
2	6.6	6.7	3.35	1.65	3.35
3	14.9	10.1	3.40	1.66	3.37
4	26.6	18.4	3.30	1.66	3.35
5	41.8	16.85	3.45	1.67	3.37

It will be seen that these results show clearly that the acceleration is constant, that s is proportional to t^2, and that v is proportional to t, the two latter facts, though not independent of the first, being more usefully illustrated directly, for junior students, than deduced from the first, or *vice versâ*.

The value of g can also now be at once found, if the period of the spring be known; a frequency of from 15 to 20 is suitable, giving, on a two-foot board, curves easily measured with sufficient accuracy with

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a metre-scale, reading all lengths to the nearest millimetre, or at most, half-millimetre, as in the example given. In this case, the spring had a frequency of 17.14, and using the value of the acceleration obtained from the greatest displacement (41.8 cm., $t = 5$), we have

$$a = \frac{2s}{t^2} = \frac{83.6}{25} \text{ cm. per "}t\text{" per "}t\text{,"}$$

where t is the period of the spring, or

$$g = \frac{83.6}{25} \times (17.14)^2 \text{ cm. per sec. per sec.}$$

$$= 982.3 \text{ cm. per sec. per sec.}$$

In the example quoted, the frequency was measured by means of an auxiliary spring, fitted with inked brush also; it was adjusted so as to vi-

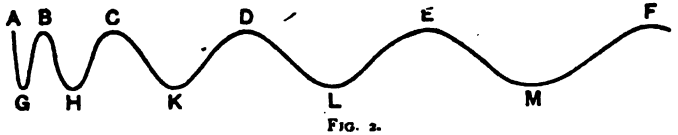

FIG. 2.

brate sufficiently slowly to admit of counting and timing with a stop-watch; its period was then compared with that of the spring in use by allowing the falling plate to move slowly down, both brushes making a trace on it. A comparison of the curves gave the ratio of the periods.

Various further illustrations of uniformly accelerated motion can be taken from the results; the equations $s = \frac{1}{2}at^2$, $v = at$, $v^2 = 2as$, for motion from rest, are at once verified, while by starting measurements from various points on the curve, the more general equations, $s = ut + \frac{1}{2}at^2$, $v = u + at$, $v^2 = u^2 + 2as$, can be readily shown to be applicable.

It is perhaps worthy of mention that the apparatus was worked out, and in use, before the Fletcher trolley was brought to the writer's notice. The trolley has added immensely to the science teacher's resources in the way of experimental illustration of motion, and the apparatus here described can only claim to deal with one case, but that case is of such importance that a simple method of demonstrating its features may prove of use.—[*School World.*

ILLEGIBLE SIGNATURES.

"Can you decipher that written signature?" says the employer to his stenographer, handing her a letter with a signature that he had tried hard, but in vain, to read. The employee makes a protracted attempt, but is unsuccessful. The letter with the illegible signature goes the rounds of the office, but with no favorable result. The letter is an important one, and cannot be answered until the sender has sent several letters of inquiry, in the last one of which his signature has been written fairly legibly. Much valuable time is thus needlessly wasted.

To obviate any similar trouble, Rear Admiral Spencer S. Wood, commandant of the First Naval District, has issued an order that, hereafter, when any officer has to sign his name to an official document, he must first typewrite it and then write it underneath in his own hand.

We commend this practice to those who habitually write their names in characteristic but illegible fashion. An excellent substitute might be for the stenographer to typewrite, in conjunction with her own initials, the full name of the writer.—[Photo-Era.

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THE AMERICAN SOLDIER.

By Antoinette Funk.

When a man is selected for military service the immediate anxiety, the immediate concern, is his destination, his housing, feeding, clothing, and health.

The new soldier is under the direction of the Provost Marshal General's department from the time he is accepted until he takes train for the camp he is assigned to. Then the transportation department takes him in charge. If his journey is a long one he travels by Pullman or tourist sleeper. Meals are provided to him along the way, at a maximum cost of sixty cents by the Government.

Under a recent ruling the selected man is immediately given an arm-band. This is an insignia of military standing and is worn until he is fitted with a uniform. This arm-band carries the same authority, protection, and responsibility that the uniform does. The enemy would have a right to fire upon him or take him prisoner, and anyone selling him liquor would be subject to prosecution under the federal law.

Arriving at his cantonment the soldier is assigned to quarters, usually in a two-story wooden building, with plenty of air and sunlight, and with the cleanest of floors—floors that would meet the old-time test "clean enough to eat from." He sleeps in a well-ventilated room with other soldiers, but not too many, the number being regulated by the cubic feet of air space in the chamber. The army bed is an extra width cot with good steel springs and bedding suited to the weather and climate; never less than two blankets are assigned him, all-wool blankets, khaki color. Sometimes he gets three and two thick comforters more if weather demands.

Lavatories are located at the rear of these quarters, with water pressure and fixtures of a design similar to that used in the best hotels in the country, and for every company unit there are from four to six shower baths. Cleanliness of person and surroundings are absolute requirements of the United States Army. Every possible precaution is taken by the sanitary corps to insure that the camp conditions are 100 per cent sanitary.

Drainage is installed along strictly scientific lines, and the most scientific disposition is made of all camp sewage. During previous wars more men have died from preventable disease than from bullet wounds. During the Civil War soldiers perished by thousands from typhoid, camp fever, dysentery, and kindred diseases resulting from unsanitary conditions about the camp. Those days are gone. Surgeon General Gorgas, who made the building of the Panama Canal possible by draining the Canal Zone and fitting it for human habitation, is in charge of the army sanitation.

As soon as the soldier is assigned to quarters he is given the most searching physical examination. All scientific medical tests are applied to detect disease. For instance, if there are indications of tubercular infection the patient is put under observation that there may be no mistake in the diagnosis. If there is incipient trouble he is sent to one of the army sanitariums and restored to health. If his case is advanced he is relieved from military service or exempted until physically fit.

Besides the examining surgeon there is the dentist. Teeth are put in good condition here, and there are dentists overseas to keep them in good condition. Also there is an orthopedic surgeon to examine the soldier's foot. It has been said that during past wars there were more desertions from foot trouble than all other causes combined. The

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attention given to the selection of shoes for the soldiers in the American army is a sidelight on the care we give our fighting men.

When a soldier gets his first pair of shoes he gets a pair that fit his feet. No account is taken of the size he wore before. His feet are placed in a cunningly devised form where the length and width are exactly determined. He bears his weight on this little machine and an officer and a noncommissioned officer take the size record of both feet, his name, company, and regiment. Then he puts on a pair of shoes of the size called for. But that doesn't end it. There is a further device that checks on the measuring machine and catches any human error in recording. This is put inside his shoe and he runs down an incline of thirty degrees, striking his heels on the cleats nailed to it. If this little machine does not make itself felt and the shoe after examination by an officer is found to be satisfactory, the man is fitted and his size is added to his service record.

Our soldiers are provided with clean socks, and at the end of long marches the feet are carefully inspected by the surgeon in charge.

No army in the world has ever attained such a health record as ours, the death rate being eight out of every thousand, here and abroad. This would be even lower but for the large number of men who come down with diseases to which they were exposed before leaving home.

The average gain in weight of the American soldiers since entering the service is twelve pounds per man.

IRON ORE AND PIG IRON IN 1917.

Statistics compiled under the direction of E. F. Burchard of the United States Geological Survey, Department of the Interior, show that the iron ore mined in the United States in 1917 reached a total of 75,288,851 gross tons, and exceeded the former record output of 1916 by 121,179 tons. The shipments from the mines in 1917 were 75,573,181 gross tons, valued at $238,260,333, a decrease in quantity of 2,297,372 tons, or 2.95 per cent, and an increase in value of $56,358,056, or 30.98 per cent, as compared with shipments in 1916.

Iron ore was mined in twenty-five states in 1917 and twenty-four in 1916. California, Montana, and Nevada produced iron ore for metallurgic flux only; part of the output of Colorado, New Mexico, and Utah was used for smelter flux and part for pig iron and ferro-alloys; the remaining states produced iron ore mainly for use in blast furnaces, except small quantities used for paint from Michigan, New York, Wisconsin, and Georgia. The ore output of Minnesota, Michigan, and Alabama, the states which have for many years produced the largest quantities of iron ore, was respectively 44,595,232 tons, 17,868,601 tons, and 7,037,707 tons, and was close to that of 1916, Minnesota having shown an increase of .02 per cent, Michigan a decrease of 1.1 per cent, and Alabama an increase of 4.3 per cent. More than 1,000,000 tons of ore each was produced also by New York and Wisconsin in 1917.

The principal iron-mining districts in the United States, except the Adirondack and Birmingham districts, are interstate, so that statistics of production by districts are also of interest and importance. The Lake Superior district mined 63,481,321 tons of ore in 1917, or nearly 85 per cent of the total, and the Birmingham district mined 6,187,073 tons, or more than 8 per cent. There were small decreases in output from the Lake Superior, Chattanooga, and New York-New Jersey districts, and increases in the Birmingham and Adirondack districts, the production from the Adirondack district having again exceeded 1,000,000 tons.

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In the Lake Superior iron-ore ranges the Mesabi mined 41,127,323 tons, a decrease of about 5 per cent from the output of 1916; the Gogebic mined 7,881,232 tons, an increase of 2.26 per cent; the Menominee 6,366,483 tons, a decrease of 4.26 per cent; the Marquette 4,638,374 tons, a decrease of 3.22 per cent; the Vermilion 1,481,301 tons, a decrease of 13.09 per cent, and the Cuyuna 1,986,608 tons, an increase of 27.7 per cent, as compared with 1916.

The imports of iron ore in 1917, according to the records of the Bureau of Foreign and Domestic Commerce, were 971,663 gross tons, compared with 1,325,736 tons in 1916.

SAMUEL W. WILLISTON.

The unexpected death at the Presbyterian Hospital in Chicago, after a surgical operation for cancer, of Samuel Wendell Williston, Professor of Paleontology in the University of Chicago, brought to the scientific world the loss of one of its ablest and most versatile members. As a paleontologist he was a foremost authority, and among the books that brought him greatest fame were *American Permian Vertebrates* and *Water Reptiles of the Past and Present*. He was a voluminous contributor also to the literature of entomology, zoology, sanitation, and comparative anatomy.

For many years Professor Williston was connected with Yale University and served as the health officer of New Haven. Later he became professor of historical geology and anatomy and dean of the medical school at the University of Kansas. For the last sixteen years he was professor of paleontology at the University of Chicago, where the results of his research attracted wide attention among scientific men.

Dr. Williston had many honors conferred upon him by scientific societies and institutions, among them being membership in the National Academy of Sciences, the presidency of the honorary scientific society of Sigma Xi, and the presidency of the Society of Vertebrate Paleontology. His reputation abroad was recognized by his appointment to represent the United States Government in the International Congress of Scientists at Monaco in 1913.

ESCAPED OFFICERS SAY AUSTRIANS AS A PEOPLE DETEST THE GERMANS.

Three Italian officers who succeeded in escaping from Austrian concentration camps gave interviews on the conditions in the interior of Austria when they arrived in Italy. They said the middle class and those who do not own real estate suffer extreme privation, although the farmers and workmen live far better.

The prisons and concentration camps are charnels, owing to the lack of food, of clothes, and of medicines.

All of the officers agreed in saying that the Austrians detest the Germans.

Whenever Germans enter a cafe, or other public resort, the Austrians who happen to be within leave the place forthwith. They are all tired of the war and the news from the front finds the public altogether indifferent.

The food supply outlook for next winter, owing to the shortage of the harvest, is discouraging. During their long stay and their journey through Austria the only thing the people discussed with any interest was how to get food.

They added that many officers in the Austrian army refuse to salute the Germans.

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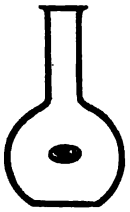

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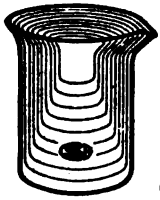

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If he needs an artificial limb or mechanical appliance the Government will supply it free, will keep it in repair, and renew it when necessary. If after his discharge he again needs medical treatment on account of his disability, the Government will supply it free. While he is in the hospital and while in training afterwards the soldier or sailor will receive compensation as if in service and his family or dependents will receive their allotment.

A wounded soldier or sailor, although his disability does not prevent him from returning to employment without training, can take a course of vocational training free of cost and the compensation provided by the war-risk insurance act will be paid to him and the training will be free, but no allotment will be paid to his family.

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NUMERICAL PROBLEMS IN CHEMISTRY.

By Jessie Caplin,
West High School, Minneapolis, Minn.

I require that stochio-chemical problems shall be solved in this way:

1. Equation.
2. Known and unknown quantity.
3. Combining weights or volumes (two only).
4. Proportion.

I try to impress the fact that these are types of real problems. After working on a few in the text, I require that pupils shall state and solve their own. Work is assigned like this:

Using any (given) equation,

1. State and solve a problem involving weights:
(a) Known and unknown in first member.
(b) Known and unknown in second member.
(c) Known in first, unknown in second.
(d) Known in second, unknown in first.
2. State and solve a problem involving weight and volume:
(a) Volume unknown.
(b) Volume known.
3. State and solve a problem involving volumes only.
4. Similarly for Boyle's and Charles's Law:

I teach the use of logarithms and encourage their use in the solution of Boyle's and Charles's Law problems. In the other kinds of problems, I encourage the children to estimate the answer.

QUICKSILVER PRODUCTION IN FIRST HALF OF 1918.

The production of quicksilver in the United States during the first half of 1918 was 17,576 flasks, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior. The total production in 1917 was 35,954 flasks. With the enlargement of our Army the demand for quicksilver is likely to be considerably greater in 1919 than in 1918, and the perfection of satisfactory detonators for high explosives that shall contain little or no mercury is one of the urgent problems of chemistry as applied to war.

The decline in production during the first half of 1918 was due chiefly to the shortage and the increased cost of labor and to the exhaustion or depletion of known ore bodies under the stimulus of high prices for the metal. The practice at some of the larger mines has been to devote nearly all energy to getting out ore and to postpone the underground exploration and development that are necessary to insure long-continued steady production.

Quicksilver mining is full of uncertainties, and capitalists are slow to invest extensively in an undertaking whose future can be so little foreseen. There is opportunity here for patriotism to cast the deciding vote where the cold doctrine of chances might turn the investor to industries offering greater assurance of reward.

One of the notable achievements in the industry during the year has been the successful adaptation of the rotary cement kiln to quicksilver metallurgy. Eight of these furnaces are now or will soon be in operation in California, and they are expected to make an increase in production that may more than offset the falling off during the first half of the year.

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ITALIAN DIRIGIBLES SHOW 109 ACTIONS WITH ENEMY IN ONE YEAR.

The Secolo has received word from a correspondent at the front that four Italian dirigibles were in 109 actions with the enemy between August last year and September 1, this year, and threw several tons of explosives on enemy works and objectives.

Three dirigibles were in twenty-five actions last July and in thirty-three in August. Italian airships altogether navigated 290 hours, covering 18,500 kilometers in their courses and dropping forty tons of explosives.

The record for the heaviest cargo dropped is held by the dirigible commanded by a captain with a marvelous service record. He has fought in forty-four actions. In August he effected seven bombardments, going on one occasion over the fields of Feltre and dropping 7,200 kilos of bombs.

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Next is an aeroplane commanded by a valiant major who is the ace of our flyers. He has made forty-nine flights and accomplished eight bombardments. Among his feats was the passage of the Alps through the Trentino, surmounting Carre peak, 3,465 feet high, the highest of the Adamello.

The other two dirigibles were commanded respectively by a captain with twenty-one actions to his record and by a captain with twenty-five. One achieved four bombardments and the other three.

BOOKS RECEIVED.

General Science and the Economics of Daily Life, by Herbert Brownell, Teachers' College, University of Nebraska. Pages xi+383. 14x20 cm. Cloth. 1918. $1.00 net. P. Blakiston's Son & Co., Philadelphia, Pa.

Starved Rock State Park and its Environs, by Carl O. Sauer, Gilbert H. Cady and Henry C. Cowles, the University of Chicago. Pages x+148. 40 figures. 2 maps. 17x24.5 cm. Cloth, 1918. $2.00 net. The University of Chicago Press.

Surgical Nursing in War, by Elizabeth R. Bundy, Woman's Hospital, Philadelphia. Pages vi+184. 12x18.5 cm. Cloth, 1918. 75 cents. P. Blakiston's Son & Co., Philadelphia, Pa.

Elementary General Science, by Daniel R. Hodgdon, State Normal School, Newark, N. J. Pages xxii+553. 15x20.5 cm. Cloth. 1918. $1.50. Hinds, Hayden and Eldredge, Chicago.

United States Official Postal Guide. 830 pages. 17x25 cm. Cloth. 1918. $1.00. Post Office Department, Washington, D. C.

The Waterbugs and Their Cousins, by Charles D. Lewis, Berea College, Normal School. Pages xii+172. 13.5x19.5 cm. Cloth. 1918. $1.75. J. B. Lippincott Company, Philadelphia.

Four-Place Logarithmic and Trigonometric Tables, together with Interest Tables, by Louis C. Karpinski, University of Michigan. 30 pages. 13x19 cm. Paper. 1918. 30 cents. George Wahr, Publisher, Ann Arbor, Mich.

A Study of Engineering Education, by Charles Riborg Mann, The Carnegie Foundation for the Advancement of Teaching. Pages xi+139. 18.5x25 cm. Paper. 1918. The Foundation, 576 Fifth Avenue, New York City.

BOOK REVIEW.

Progressive Chemistry, a Laboratory Manual, by P. A. Davis, North High, Louis G. Cook, East High, B. T. Emerson, Central High, Jessie F. Caplin, West High, and Kate McDermid, South High, Minneapolis, Minn. 3d edition, revised. Pp. ..... 45 exps. No diagrams. Pasteboard back, perforated and punched. 1918. Printed for the authors. Mail address: Kate McDermid, South High, Minneapolis.

The particular virtues claimed for this laboratory manual by the authors are: (1) no diagrams, so apparatus can be used as supplies permit; (2) test tubes are used in place of flasks, or bottles are thus used; (3) quantities of materials called for are the minimum quantities that will serve the purpose; (4) measurement of quantity is by spoonfuls, except where accuracy is necessary or where some special end is in view or where materials are costly; (5) the questions used are such as tend to induce thought; (6) summaries of the experiments are called for, so pupils must review the experiment in hand and often previous experiments.

The forty-five experiments cover a wide range of topics, many of the later ones giving glimpses of qualitative analysis or of applied chemistry.

F. B. W.

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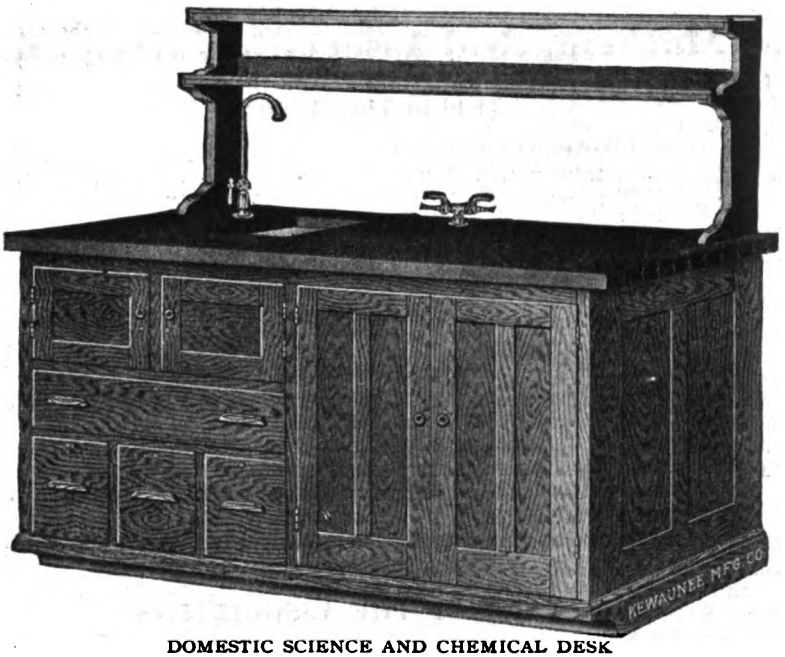

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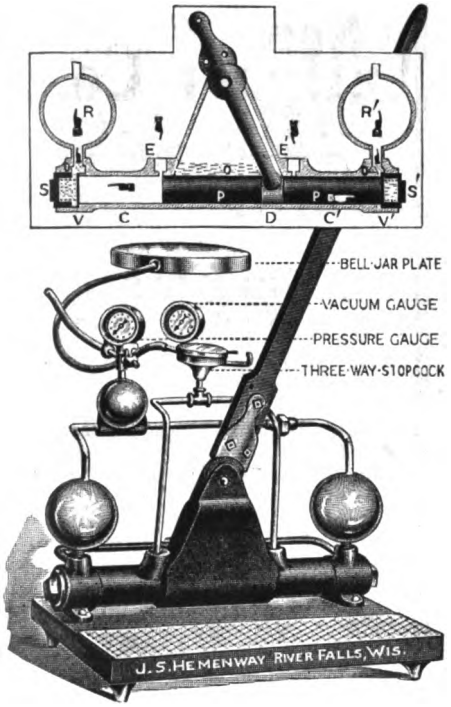

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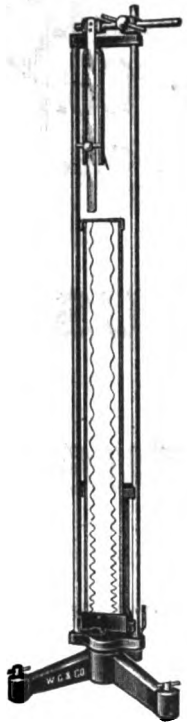

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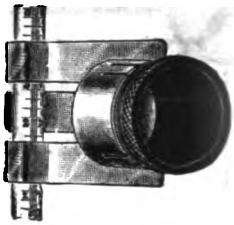

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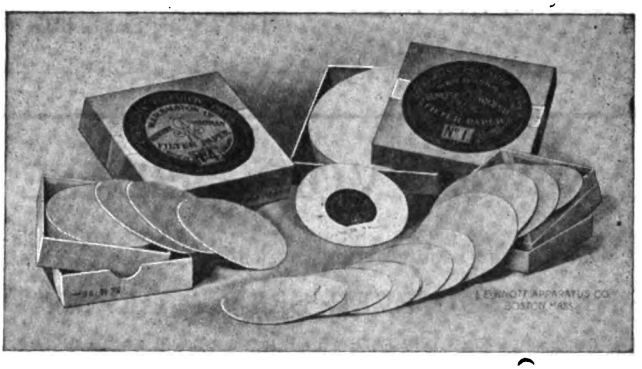

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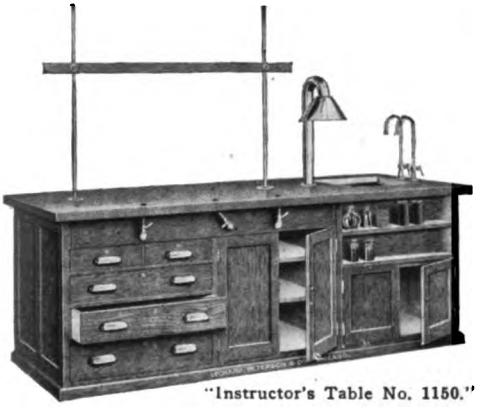

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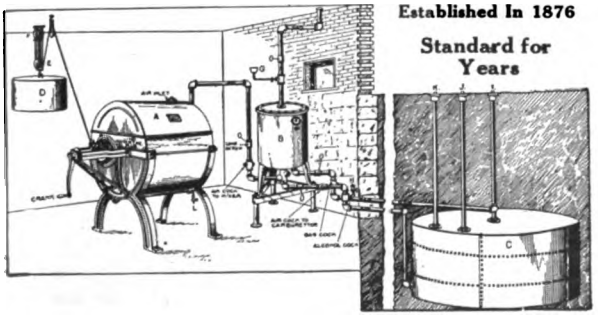

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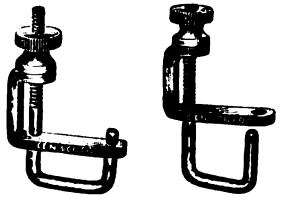

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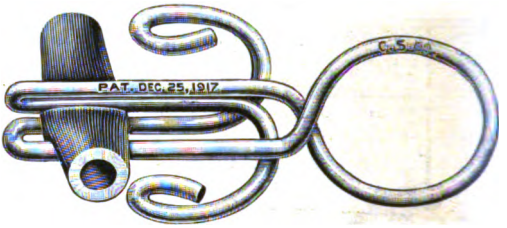

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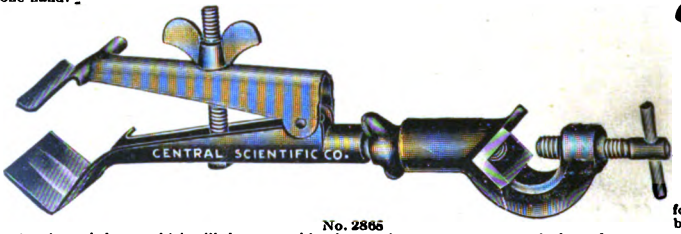

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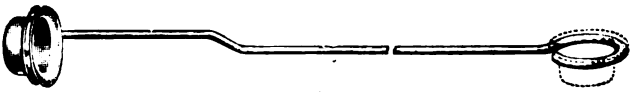

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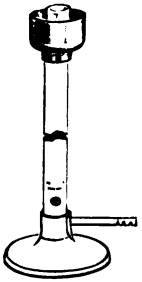

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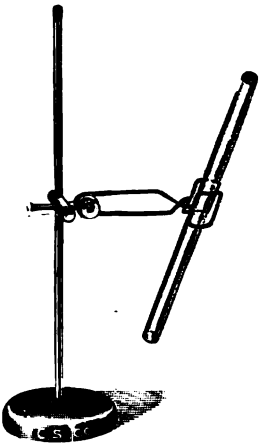

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